Revised Interim Measures Work Plan
Sub-Areas 2B and 6B
The Boeing Company, Tract 1
Hazelwood, Missouri

Prepared for:

The Boeing Company
Boeing Defense, Space and Security
P.O. Box 516, MC S111-2491
St. Louis, MO 63166-0516

Prepared by:

RAM Group of Gannett Fleming, Inc.
5433 Westheimer Road, Suite 725
Houston, TX 77056
Ph: (713) 784-5151
Fax: (713) 784-6105
e-mail: asalhotra@ramgp.com

March 12, 2012

RCRA

516883

The Boeing Company
P.O. Box 516
St. Louis, MO 63166-0516
(314) 232-0232

March 12, 2012
107A-6649-JWH

Ms. Christine Kump-Mitchell, P.E.
Environmental Engineer, Permits Section
Missouri Department of Natural Resources
Hazardous Waste Program
7545 South Lindbergh
St. Louis, MO 63125

BOEING

Re: Response to Comments Received from MDNR and St. Louis Lambert International Airport on the Interim Measures Work Plan Sub-areas 2B and 6B, Dated December 2011, The Boeing Company Tract I Site, Hazelwood, Missouri, MOD000818963

Dear Ms. Kump-Mitchell:

This letter provides response to the 27 January 2012 letter from the Missouri Department of Natural Resources (MDNR) and the 24 January 2012 letter from the St. Louis Lambert International Airport (Airport) which contain comments on the *Interim Measures Work Plan Sub-areas 2B and 6B* (the Work Plan), dated December 2011. Additionally, these responses have been incorporated into a Revised Work Plan, dated 12 March 2012; a hardcopy of which is enclosed with this letter.

As stated in Section 1.1 of the Work Plan, these supplemental interim measures in Sub-areas 2B and 6B are being conducted, with input and coordination with MDNR, to evaluate the opportunity to proactively reduce concentrations of chlorinated solvents that remain in these two sub-areas. These activities are being performed as a supplement to the remedy specified in the *Corrective Measures Study* (CMS) for the Boeing Tract I Site (submitted by RAM Group of Gannett Fleming, Inc., dated February 16, 2012) because of a potential opportunity to decrease highest concentrations relatively quickly with little disruption or impacts to other ongoing facility operations. These actions are not required elements of the CMS because past interim measures and other elements of the final CMS fully address all risks identified at the site.

The applicability of in-situ chemical oxidation (ISCO) as an interim remedial measure will be tested at the site by an initial injection event analogous to a pilot test to evaluate whether trial injections of oxidant are effective in reducing residual concentrations of chlorinated solvents and their daughter products in the two sub-areas. Because this remedial action is not risk-driven, the strategy for applying ISCO at the Tract 1 Site has been modified from the approach specified in typical ISCO guidance documents such as the Interstate Technology & Regulatory Council's (ITRC) guidance document entitled *"Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater"*, dated January 2005. The general strategy for applying ISCO at Sub-areas 2B and 6B is to proceed with initial pilot test injections of sodium permanganate and closely monitor results to check and re-adjust the plan based on test results. This approach should optimize the benefits of remediation, above and beyond that required by the risk-based remedy specified in the CMS. This flexible approach will also allow unnecessary disruptions to current property owners and ongoing facility activities to be minimized.

Following MDNR's approval of this Work Plan, a contractor will be selected to implement the scope of work. This Revised Work Plan specifies the framework and program to be used for this interim measure and the response to comments provided herein identify that a few of the details that are dependent on input from the selected implementation contractor will be identified at a later time.

If you have questions regarding the responses or enclosed submittal, please contact me at (314) 777-9181 or Dr. Atul Salhotra of the RAM Group of Gannett Fleming, Inc. at 713-784-5151.

Sincerely,

Joe Haake

Joseph W. Haake
Environmental Scientist

Encl: Revised Interim Measures Work Plan Sub-Areas 2B and 6B, dated March 12, 2012

cc: Mr. Rich Nussbaum, MDNR
Mr. Bruce Stuart, MDNR
Ms. Amber Whisnant, USEPA Region VII
Ms. Joletta Golik, St. Louis Lambert International Airport

RESPONSE TO COMMENTS

MDNR General Comments

1. Boeing must follow all applicable Missouri laws and regulations; including 10 CSR 23-1 to 10 CSR 23-4 that address permitting and reporting of well construction during the implementation of the work plan. Please contact the Department's Wellhead Protection Section for more information, if needed, at (573) 368-2165.

   Response: Agreed. All well permitting and construction will be done per *Missouri Well Construction Rules* which incorporate 10CSR23-1 thru 10CSR23-6. As confirmation, this statement has been included in Section 3.2.1 of the Work Plan.

2. The work plan should include all of the items identified in the UIC Checklist. Information that has been provided previously in the RFI or other applicable documents should be either described in the work plan or included in an appendix when possible. Items that are too large to incorporate into the work plan may be referenced, provided sufficient detail is supplied to easily locate the required information in the referenced documents. A copy of the completed UIC checklist is attached. All of these items must be provided prior to obtaining approval for injection activities. Checklist items not in the current draft work plan include:

   a. Facility and owner information for the site;
   Response: The owner and operator of Sub-area 2B is the Lambert – St. Louis International Airport; although, there are no current operations in this sub-area. The owner and operator of Sub-area 6B is GKN Technologies. These statements have been added to Section 1.1.

   b. Cross section of site that includes depth to bedrock, depth to water bearing zone(s), depth of injection, area of soil and groundwater contamination, utilities, septic tanks system, etc;
   Response: Figures 2-3 and 2-6, geologic cross-sections, have been added for Sub-areas 2B and 6B, respectively.

   c. Geological features present within a quarter mile radius of site;
   Response: Figure 2-5 from the RFI (MACTEC, 2004) presents the bedrock geology of the site and vicinity. A copy of Figure 2-5 has been included in Appendix A. A detailed discussion of the bedrock geology is provided in the RFI.

   d. Schematic of injection wells;
   Response: The intent is for oxidant to be injected via direct push and no constructed injection wells are planned. Additional details regarding design of the direct-push injection program have been incorporated in Section 3.1 of the Work Plan.

   e. MSDS for injected material and literature research if biological agents are introduced;
   Response: Sodium permanganate is proposed as the oxidant to be injected in both Sub-areas 2B and 6B. Once the implementation contractor has been selected (following approval of this Revised Work Plan), a MSDS for the material to be injected will be obtained from the supplier and provided to the MDNR prior to injection. No biological agents are planned for injection. This has been clarified in the Work Plan in Section 3.3.

f. Volume of chemical to be injected;
Response: Injection locations, intervals and range of volume of oxidant to be delivered are provided in Table 3-3. However, these may be adjusted pending results of the limited direct-push investigation activities, monitoring well installation, and input provided by the implementation contractor.

g. If injected into an aquifer, explain how the injected chemicals will be withdrawn or reduced to pre-injection levels;
Response: Sodium permanganate is identified as the oxidant to be injected in both Sub-areas 2B and 6B. When sodium permanganate is injected into the groundwater zone, sodium permanganate disassociates into sodium cations and permanganate anions. From there, the permanganate can completely oxidize organics (specifically for the Boeing Tract I Site – PCE, TCE, DCE, and vinyl chloride) to chloride, carbon dioxide and water. Permanganate can also react with water, but at a slower rate than it oxidizes organics. When reduced contaminants are no longer available to react with permanganate, this slow decomposition process eventually results in depletion of excess permanganate that may remain in the subsurface after injection and treatment. As noted in Table 3-1, manganese will be monitored prior to and following injection to evaluate potential impact of injected materials in the subsurface. Statements have been added to Section 3.3 of the work plan to reflect this response.

h. The following information should be collected for each hydraulically distinct zone into which injection is to occur both prior to and following injection: BOD, COD, TOC, Ammonia as N, groundwater flow velocity, directions, gradients, temperature and pH;
Response: Monitoring locations and parameters to be collected prior to and following injection are documented in Table 3-1, demonstrating the collection of appropriate parameters in each hydraulically distinct zone. The basis for design of the pilot tests for Sub-areas 2B and 6B is to conduct trial injections of oxidant and determine if they are effective in reducing residual concentrations of chlorinated solvents. To meet the specific needs of this supplemental action, sampling will be conducted for the following parameters: dissolved oxygen, pH, oxidation reduction potential, specific conductance, temperature, alkalinity, chloride, total and dissolved manganese, total and dissolved iron, ethane, ethane, methane, and carbon dioxide.

i. A listing of other wells at the site, including active domestic, commercial and industrial use wells, abandoned water wells, aquifer recharge wells; aquifer remediation wells; industrial drainage wells; and others not specifically listed;
Response: There are no active domestic, commercial, or industrial use wells, abandoned water supply wells, aquifer recharge wells, aquifer remediation wells, or industrial drainage wells located at the site. The only wells at the site are active and abandoned monitoring wells and piezometers that have been used for gauging groundwater depths and sampling groundwater for field and laboratory analysis. This statement has been added to Section 1.1. The active and abandoned monitoring wells in Sub-area 2B and Sub-area 6B (North) are presented in Tables 2-2 and 2-4, respectively.

j. If injection wells are to be cased, a permit or other approval may be required from DGLS; and
Response: Per response to General Comment 2.d. above, oxidant will be injected via

direct push and no constructed injection wells are planned.

k. A geologist or professional engineer registered in Missouri must seal any documents proposing subsurface injection of materials for remediation purposes and/or evaluation of the efficacy of such remediation.
Response: A signature page has been added and includes the signature and seal of a professional engineer registered in the State of Missouri.

3. There are several design and implementation considerations that must be evaluated while selecting the type of in-situ chemical oxidation to use for remediation of chlorinated hydrocarbons. These include:

- Determine if venting or negative pressure systems are necessary with ozone or Fenton' reagent to accommodate off-gasses and relieve pressure and buildup of organics. This consideration is especially important if the ground surface is paved;
Response: The proposed oxidant, sodium permanganate, does not create significant elevated pressures or temperatures that could potentially cause undesired vapor or dissolved phase migration. For documentation purposes, a statement to this effect has been added to the Work Plan in Section 3.3. Note that Sub-area 2B is not paved and Sub-area 6B is paved.

- Conduct utility surveys to account for the effect of underground piping, utilities, or trenches on preferential pathways and or pockets of organic decomposition, explosive liquids and vapors, and oxygen;
Response: Figure 5-1 of the RFI indicates the locations of utilities in Sub-area 2B. This figure shows a natural gas line that runs north-south between MW-9S and MW-10S and the locations of abandoned fuel lines that were removed during the SWMU 17 excavation. Figures 2-2 and 2-3 in the Work Plan show the approximate location of the natural gas line. Figure 4-4 of the RFI indicates the locations of utilities in Sub-area 6B. There is an industrial sewer line in this sub-area. Figures 2-5, 2-6, and 3-2 in the Work Plan show the approximate location of the industrial sewer line. These statements have been included in Sections 2.1.1 and 2.2.1. Copies of the RFI figures are provided in Appendix A.

- Evaluate the potential impacts Hydrogen Release Compound® (HRC®) may have on in-situ chemical oxidation effectiveness; and
Response: We recognize that past additions of HRC may affect in-situ chemical oxidation (ISCO) effectiveness which is why we have recommended a flexible approach with trial injections to determine the effectiveness of ISCO in Sub-areas 2B and 6B. The program will include collection of soil samples for permanganate demand analysis from each sub-area. Results will be used, as appropriate, to confirm oxidant dosage and volume to be injected at each proposed direct-push injection location. Statements have been added to Section 3.3 of the work plan to reflect this response. Also, additional details regarding the limited investigation and sampling efforts prior to injection have been incorporated in Section 3.0 of the Work Plan.

- Address the specific health and safety issues related to using in-situ chemical oxidation and the relationship of the oxidant to chemicals in the soil and groundwater. This would

include the need to monitor temperature, pressure, carbon dioxide emissions, and lower explosive limits. These parameters may differ depending on the oxidant selected.

Response: Sodium permanganate is identified as the oxidant of choice. Oxidant will be delivered as a liquid solution, which reduces the amount of handling required and eliminates the need for onsite mixing. A project-specific health and safety plan (HASP) will be prepared by the contractor selected to implement the pilot test. The HASP will document specific health and safety related issues, including proper handling of oxidant, spill prevention and control, personal protective equipment (PPE) requirements and monitoring, as necessary. Statements have been added to Section 3.3 of the work plan to reflect this response. Monitoring locations and parameters to be collected prior to and following injection are documented in Table 3-1.

MDNR Specific Comments

4. **Section 1.1 Background and Introduction, Page 1-1:** The introduction should include the facility location and ownership information. In addition to the figures, the work plan should include a more detailed description of the location and ownership information for the two injection sites.

   Response: Sub-area 2B is currently owned by the City of St. Louis, a Municipal Corporation of the State of Missouri and the owner and operator of Lambert – St. Louis International Airport. Sub-area 2B is located south of Banshee Road near the west end of Tract 1 South between Sub-area 2A (to the west) and Sub-area 2C (to the east), and north of Area 1 as shown on Figure 1-1.

   The current owner and operator of Sub-area 6B is GKN Aerospace. Sub-area 6B is located on Tract 1 North between Building 27 (to the east) and Building 29 (to the west), north of Banshee Road and to the south of Area 7 as shown on Figure 1-1. Sub-area 6B includes Buildings 22, 28, and 39.

   The above statements have been added to Section 1.1.

5. **Section 1.1 Background and Introduction, Page 1-1:** This section states "for both sub-areas, in-situ chemical oxidation would be evaluated to destroy the mass of chlorinated solvents in soil and groundwater and to reduce the groundwater concentrations". The work plan does not discuss the type of oxidant that will be used. If Boeing is still in the oxidant selection process then the work plan should include that fact along with the oxidant options that are being evaluated and a proposal and schedule for submitting the information. Once an oxidant chemical product is selected the design of the in-situ chemical oxidation procedures should be discussed. This should include the dose of the oxidant required to degrade the contaminant in the sorbed phase, dissolved phase, and if present the NAPL phase, desired radius of influence, the oxidant delivery method, the MSDS of the chemical and an explanation of how the injected chemical will be reduced to pre-injection levels. Different oxidants will have different design considerations. This information must be submitted prior to obtaining approval for injection activities.

   Careful site characterization, screening and feasibility are necessary to determine the type, amount, and applicability of in-situ chemical oxidation. The conceptual site model as it applies to

the selection of oxidants should also be discussed. Because of the reactivity of the oxidants, there is a potential to cause significant changes in both the concentration and distribution of contamination, potentially resulting in large changes in the site's established equilibrium of the contaminants between the vapor, liquid and sorbed phases. Therefore it is important to know the concentrations of constituents in the soil and groundwater. It is also important to know what metals are present in the soil and groundwater because in-situ chemical oxidation can oxidize some metals including iron, cadmium, and selenium to a more soluble form, increasing their migration potential. These reactions can also create additional demand of the oxidant and require increased dosing. In addition, manganese concentrations should be determined if permanganate is to be used, as elevated manganese could cause the potential for manganese dioxide precipitation and clogging of aquifer pore space. Additional data needs may be necessary depending on the oxidant chosen. Additional information can be found in the Interstate Technology & Regulatory Council's (ITRC) guidance document entitled *"Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater"*, dated January 2005.

Response: Section 3.3 of the Work Plan has been revised to indicate that sodium permanganate will be the oxidant injected in sub-areas 2B and 6B. Sodium permanganate was selected because it is effective for rapidly reducing high concentrations of chlorinated ethenes like the targeted VOCs for both sub-areas and can be injected in liquid form, which reduces handling and the need for onsite mixing. Additionally, it has a slightly longer persistence to facilitate enhanced distribution following injection.

ISCO is being evaluated as a supplemental action to evaluate the potential to further reduce the highest concentrations at two source areas of highest residual contaminant concentrations. These activities are being performed as a supplement to the remedy specified in the CMS because the contaminant mass targeted by ISCO is already below acceptable risk-based cleanup levels. Because this remedial action is not risk-driven, the strategy for applying ISCO at the Tract 1 Site has been modified from the approach specified in typical ISCO guidance documents such as the guidance document entitled *"Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater"* (ITRC, 2005). The general strategy for applying ISCO at Sub-areas 2B and 6B is to proceed with a defined plan, as described in the Work Plan, but closely monitor results to check and re-adjust the plan based on test results. Table 3-1 outlines the monitoring program for groundwater sampling and oxidant monitoring following injections. The results of the post injection monitoring will be compared with the direct-push and baseline monitoring results to evaluate for the presence of adverse changes in the groundwater quality. This approach should optimize the benefits of remediation, above and beyond that required by the risk-based remedy specified in the CMS, while reducing unnecessary additional remediation that does not significantly reduce long-term uncertainties. This flexible approach will also allow unnecessary disruptions to current property owners and ongoing facility activities to be minimized.

6. **Section 2 Background Information, Page 2-1:** This section refers to the site-specific references in Section 5 for additional information on localized source areas, geology and hydrogeology, and interim measures. Information that has been provided previously in the RFI or other applicable documents should be either described in the work plan or included in an appendix when possible. However, items that are too large to incorporate into the work plan may be referenced, provided

the specific reference for each item is provided in the text.

Response: Additional details of referenced materials have been added to the Work Plan including specific references. Also, Appendix A has been added to include some figures from the RFI.

7. **Section 2.1.6.2, Sub-Area 2B, Deep Groundwater Zone, Page 2-3:** MW-11I and MW-11D are cross-gradient to the source area there are currently no deep wells down gradient of the SWMU. Not enough information to state that "the extent of chlorinated solvent impacts has been identified." This statement should be removed.

   Response: Agreed. The above referenced statement has been removed.

8. **Section 2.2.5.2 Sub-Area 6B, Deep Groundwater Zone, Page 2-6:** This section states that the deep groundwater zone has not been impacted based on 11 sampling events at MW-9D. MW-9D is located upgradient of MW-3. RC8D has elevated concentrations of total 1,2-DCE and TCE. There are no other deep wells in the vicinity of MW-3. This statement should be removed.

   Response: The statement is correct. There was only one deep zone screened well in Sub-area 6B and it was MW-9D; therefore, the deep zone characterization is based on this well. MW-9D for several years since 2003 could not be sampled due to artesian conditions and was abandoned in March 2011. MW-9D was sampled 11 times from 2000 to 2003 and was found not to be impacted. MW-3 and RC8D are screened in the shallow groundwater zone, not the deep zone. The Work Plan includes the installation of a deep groundwater zone monitoring well near MW-3.

9. **Section 3.1 Task 1: Initial Chemical Injection Activities, Page 3-1:** Bench scale or laboratory testing should be conducted as part of Task 1 and prior to conducting injection activities in monitoring well MW-5I in Sub-area 2B and at MW3 and MW3A in Sub-area 6B. Bench scale and laboratory testing are necessary for determining the natural oxidant demand, the soil oxidant demand, and the potential for mobilization of metals. Such testing can be used to quantify treatment efficiencies of chemical oxidants with specific contaminants in both saturated soil and the dissolved phase. Additional information can be found in the Interstate Technology & Regulatory Council's (ITRC) guidance document entitled *"Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater"*, dated January 2005.

   Response: As noted in response to MDNR General Comment #3, bullet #3, soil samples will be collected to evaluate the permanganate demand of the soil in each sub-area. Results will be used to confirm oxidant demand and volume to be injected, and to provide information as to whether previously applied HRC may impact effectiveness of planned ISCO at each sub-area. For similar subsurface conditions (i.e., low permeability soils), our experience is that characterization information such as oxidant demand, may not be particularly definable from lab bench testing and we have found that more relevant information is obtained through actual field application. Therefore, we have described a flexible approach starting with a trial injection event with our testing primarily focused on evaluating and observing the effect that ISCO has on existing groundwater concentrations. Statements have been added to Sections 3.1.2 and 3.3 of the work plan to reflect this response.

10. **Section 3.1.1, Sub-area 2B Phase 1, Page 3-1 and Section 3.1.2, Sub-Area 6B, Phase, Page 3-2:** The work plan should include a figure showing the proposed grid layout of geoprobe borings

with an acknowledgement that the number of geoprobe locations are dependent on field screening.

Response: Figures 3-1 and 3-2 show the proposed locations of direct-push borings, additional monitoring wells, and ISCO injection points for Sub-areas 2B and 6B, respectively. A statement regarding the number and locations of borings may be adjusted based on field screening has been added to Section 3.1.1.

11. **Section 3.1.2 Sub-area 6B, Phase 1, Page 3-2:** This section states that four borings will be cored near MW3 and MW3A to inject oxidants. The work plan should include a figure showing the approximate location of the 4 borings to be cored near MW3 and MW3A.

Response: See response to Specific Comment 10 above.

12. **Section 3.2 Task 2: Monitoring to Evaluate Effectiveness, Page 3-2:** This section states that selected wells will be sample to determine the effectiveness of the injections. The wells proposed to be sampled should be included, with the acknowledgement that adjustments to the number and location of wells may be needed.

This section also lists parameters that will be analyzed. Additional data need may be necessary depending on the oxidant selected. In addition, depending on the oxidant used, some parameters, such as temperature, pressure, and lower explosive limit, may need to be monitored during oxidant injection. Additional information can be found in the Interstate Technology & Regulatory Council's (ITRC) guidance document entitled *"Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater"*, dated January 2005.

Response: The monitoring program including the wells to be utilized is presented in Table 3-1 and the well construction details are presented in Table 3-2. These tables are discussed in the text as appropriate. A statement has been added to Section 3.2.1 regarding adjustments to the number and locations of wells based on the results of the direct-push investigation results. Also, see response to Specific Comment 10 above.

13. **Section 3.3 Task 3: Additional Injection of Chemicals, Page 3-3:** This section states that the exact horizontal and vertical location of injections, the amount of chemical injection will depend on the results of Task 2. The work plan should discuss submittal of an addendum that will provide this information prior to initiating Task 3.

Response: The following has been added to Section 3.6: "As tasks are completed and additional data is available to support decision making for subsequent tasks, this information will be shared with the MDNR. Interactions may include a combination of conference calls, face to face meetings, site visits, etc. This level of interaction will allow decisions to be made in the field as necessary to optimize the work."

14. **Task 3: Additional Injection of Chemicals, Section 3.3.1, Sub-Area 2B and Section 3.3.2, Sub-Area 6B, Page 3-3**: This section states that selected wells will be sample to determine the effectiveness of the injections. The wells proposed to be sampled should be included, with the acknowledgement that adjustments to the number and location of wells may be needed.

Response: See response to Specific Comment 12 above.

Airport Comments

1. **Shallow Groundwater Zone:** The extent of impact of shallow groundwater is said to be "...identified and confined to an area within about 100 feet of the excavated area..." by results at TP-4 and other locations. There follows a listing of 17 sampling locations. However, at 14 of the 17 locations, groundwater sampling was last conducted in 2001 and no recent data exist. Groundwater from location TP-4 exceeded its screening level according the 2011 Report (Table 4-3 of the 2011 Report). Therefore, it is not clear how TP-4 can be used to "confine" the groundwater impact.

   Response: Groundwater concentrations at TP-4 did exceed screening levels during the 2011 sampling event; however, the concentrations have decreased since the 2005 sampling event and appear stable with the 2008 sampling event. We have added additional data points to the table in Section 2.1.6.1 to support our statement regarding extent of impact.

2. **Deep Groundwater Zone:** The 2011 Report indicates that groundwater is significantly impacted at location MW-5I, with a concentration of 250,000 micrograms per liter (ug/L, Table 4-1 of the 2011 Report). The Work Plan states that the groundwater impact is said to be "identified" and does not extend to the "down gradient" wells MW-11I and MW-11D located about 210 feet to the east.

   However, the attached "Deep Zone Groundwater Contour Map" [Figure 2-2(b)] demonstrates that:

   1) The direction of flow of deep groundwater has been defined only by a single well in Tract I South; and
   2) The attached map [Figure 2-2(b)] supports deep groundwater flow to the south-southeast. Therefore, wells MW-11I and MW-11D do not appear to be downgradient wells. There are no deep wells located south-southeast of MW-5I that can be used to define the extent of impact to deep groundwater.

   Response: The statement has been removed. Note that additional intermediate and deep zone monitoring wells are included in the Work Plan as discussed in Section 3.2.1.

3. **Backfill of the Soil Excavation:** Section 2.1.2 of the Work Plan states that a 4-inch diameter well was installed within the backfill of the previous soil excavation. However, this well has not been sampled. This well could be sampled, potentially providing valuable information about the results of the previous soil excavation and removal action.

   Response: This well is SWMU17-OB-1 and has been sampled four times from 2008 to 2011. These data are presented in the individual groundwater sampling reports (RAM Group, 2008, 2010a, 2010b, and 2011). The chlorinated solvent data for this well is summarized in Table 2-2.

4. **Chemical Oxidizers:** Section 3.1 of the Work Plan proposed injection of in-situ chemical oxidizers (ISCO) to "...destroy the mass of chlorinated solvents and reduce the groundwater concentrations." However, the Work Plan does not state what the oxidizers will be, where they will be injected, how deep the injections will be, and what quantities will be injected. If the oxidizers are injected only to 25 feet or less, the deep groundwater chlorinated solvents demonstrated to occur at location MW-5I may not be affected.

The Work Plan states that "Initial chemical injection for ISCO will be performed at MW-5I." However, the Work Plan does not specify where the injections will occur at location MW-5I. Injection of oxidizers directly into MW-5I would render that well ineffective as a monitoring well. Figure 3-1 of the Work Plan shows a proposed well (MW-16D) near MW-5I. However, the Work Plan does not state the purpose for MW-16D and the anticipated depth of this proposed well.

Figure 3-1 of the Work Plan shows a red outline that appears to correspond to the former soil excavation area. A solid red area is also shown, which is not identified on Figure 3-1. It is unclear what the solid red area means.

Response: Additional details regarding design of the direct-push injection program have been incorporated in Section 3.1 of the Work Plan. These details include current assumptions for: oxidant to be injected; locations for limited direct-push investigation, monitoring wells, and injection points; and volume to be injected. Additional information is provided on Figures 3-1 and 3-2 and in Table 3-2 regarding monitoring locations, construction details, and rationale for selected locations. Additionally, Figure 3-1 has descriptors that show the red outline denotes the Extent of Excavation and the solid red area denotes SWMU 17.

5. **Task 5: Regulatory Interaction:** Task 5 of the Work Plan (page 3.3) states that "Boeing intends to keep the regulators informed of the activities." Relative to Tract I South, this section of the Work Plan should be altered to also state that Boeing will keep the regulators and the Owner informed of activities, so that the Airport will be fully informed and updated.

Response: Section 3.6 of the Work Plan has been updated to include that Boeing will keep the Owners informed of site activities.

Revised Interim Measures Work Plan
Sub-Areas 2B and 6B
The Boeing Company, Tract 1
Hazelwood, Missouri

Prepared for:
The Boeing Company
Boeing Defense, Space and Security
P.O. Box 516, MC S111-2491
St. Louis, MO 63166-0516

Prepared by:
RAM Group of Gannett Fleming, Inc.
5433 Westheimer Road, Suite 725
Houston, TX 77056
Ph: (713) 784-5151
Fax: (713) 784-6105
e-mail: asalhotra@ramgp.com

March 12, 2012

Revised Interim Measures Work Plan
Sub-Areas 2B and 6B
The Boeing Company, Tract 1
Hazelwood, Missouri

Prepared for:
The Boeing Company
Boeing Defense, Space and Security
P.O. Box 516, MC S111-2491
St. Louis, MO 63166-0516

Prepared by:
RAM Group of Gannett Fleming, Inc.
5433 Westheimer Road, Suite 725
Houston, TX 77056
Ph: (713) 784-5151
Fax: (713) 784-6105
e-mail: asalhotra@ramgp.com

March 2012

Atul M. Salhotra, Ph.D.
Principal Professional

Kendall L. Pickett
Senior Geologist

Clifford Coffey Wright, P.E.
Missouri Registered Professional Engineer No. 2009006638

STATE OF MISSOURI
CLIFFORD COFFEY WRIGHT
NUMBER PE-2009006638
PROFESSIONAL ENGINEER

3/12/12

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

AST	Above-ground Storage Tank
Boeing	The Boeing Company
CMS	Focused Corrective Measures Study
cm/sec	Centimeters per Second
COC	Chemical of Concern
DCE	Dichloroethene
DO	Dissoved Oxygen
ft bgs	Feet Below Ground Surface
HRC	Hydrogen Release Compound®
ISCO	In-Situ Chemical Oxidation
LNAPL	Light Non-Aqueous Phase Liquid
MACTEC	MACTEC Engineering and Consulting, Inc.
MDNR	Missouri Department of Natural Resources
MSDS	Material Safety Data Sheet
µg/kg	Micrograms per Kilogram
µg/L	Micrograms per Liter
ORP	Oxidation Reduction Potential
PCE	Tetrachloroethene
PID	Photoionization Detector
RAM	Risk Assessment & Management Group, Inc.
RAM Group	RAM Group of Gannett Fleming, Inc.
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SWMU 17	Solid Waste Management Unit No. 17
TCE	Trichloroethene
UST	Underground Storage Tank

1.1 OBJECTIVE

This document addresses the remediation of localized chlorinated solvent impacts in two source areas referred to as Sub-areas 2B and 6B in the risk assessment report (RAM, 2004). Refer to Figure 1-1 for the locations of these two sub-areas. The objective of this effort is to evaluate whether groundwater concentrations and mass of chlorinated solvents in these two source areas can be further reduced with a small-scale injection program using in-situ chemical oxidation (ISCO). The proposed effort is effectively a proactive and voluntary continuation of the previously implemented interim remediation measures in these two sub-areas.

1.2 INTRODUCTION

Sub-area 2B is currently owned by the City of St. Louis, a Municipal Corporation of the State of Missouri and the owner and operator of Lambert – St. Louis International Airport. Sub-area 2B is located south of Banshee Road near the west end of The Boeing Company (Boeing) Tract 1 South between Sub-area 2A (to the west) and Sub-area 2C (to the east), and north of Area 1 as shown on Figure 1-1. There are currently no active operations in this sub-area.

The current owner and operator of Sub-area 6B is GKN Technologies. Sub-area 6B is located on the Boeing Tract 1 North between Building 27 (to the east) and Building 29 (to the west), north of Banshee Road and to the south of Area 7 as shown on Figure 1-1. Sub-area 6B includes Buildings 22, 28, and 39.

There are no active domestic, commercial, or industrial use wells, abandoned water supply wells, aquifer recharge wells, aquifer remediation wells, or industrial drainage wells located at the site. The only wells at the site are active and abandoned monitoring wells and piezometers that have been used for gauging groundwater depths and sampling groundwater for field and laboratory analyses.

Remediation efforts have included the removal and offsite destruction of above-ground storage tanks (ASTs) and underground storage tanks (USTs), excavation and offsite disposal of impacted soils, placement of Hydrogen Release Compound® (HRC) at the bottom of an excavation in Sub-area 2B, HRC injection using Geoprobe® points in Sub-area 6B, and vacuum recovery and hand bailing of Light Non-Aqueous Phase Liquid (LNAPL) from monitoring wells in Areas 1 and 2 (MACTEC, 2004a,b, 2006a,b).

The previously completed remedial investigations, several subsequent monitoring events, and preliminary modeling results have all indicated that although the chlorinated solvent impacts in the two sub-areas have been present for several years in soil and groundwater, there is no evidence of migration beyond the immediate source areas. This is likely due to the combination of silty clay sediments; tight soils and low hydraulic gradient; and the on-going natural attenuation of the solvents. Further, the site-wide risk assessment indicated that the only unacceptable risk in these two sub-areas was potential dermal contact with the shallow

groundwater with tetrachloroethene (PCE) in Sub-area 2B and trichloroethene (TCE) in Sub-area 6B. These risks can be readily managed using institutional controls. Target concentrations for these chemicals were calculated and are presented in Sections 3.1.1 and 3.1.2 of the Focused Corrective Measures Study (CMS) (RAM Group, 2012). The target risk calculations are presented in Appendix D of the CMS.

Boeing voluntarily implemented the previously completed interim remedial measures in these two sub-areas with the concurrence of the Missouri Department of Natural Resources (MDNR). Boeing intends to further supplement the previous interim remedial measures. The intent is to evaluate if concentrations of chlorinated solvents and the daughter products can be reduced in these two sub-areas.

For both sub-areas, ISCO will be evaluated to destroy the mass of chlorinated solvents in soil and groundwater and to reduce the groundwater concentrations.

This section presents brief relevant background information for the two sub-areas. Specifically, the section focuses on a description of the localized source areas, geology and hydrogeology, and the interim measures conducted to date. The regional bedrock geology of the site and vicinity is presented in Figure 2-5 of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) report (MACTEC, 2004b). Figure 2-12 in the RFI presents the generalized hydrogeological column for the site (refer to Appendix A for copies of the RFI figures).

2.1 SUB-AREA 2B

2.1.1 Description

The Sub-area 2B was used for PCE recovery using a distillation unit. Handling of the liquid PCE resulted in spillage of PCE liquids. The primary chemicals of concern (COCs) are the chlorinated solvents and their daughter products and include:

- PCE,
- TCE,
- cis-1,2-Dichloroethene (DCE),
- trans-1,2-DCE, and
- Vinyl chloride.

Figure 5-2 in the RFI shows the extent of soil impacts identified during the RFI. Figure 5-3 in the RFI shows the extent of groundwater impacts. Figure 5-1 of the RFI indicates the locations of utilities in Sub-area 2B. This figure shows a natural gas line that runs north-south between MW-9S and MW-10S and the locations of abandoned fuel lines that were removed during the SWMU 17 excavation. Copies of these figures are provided in Appendix A.

2.1.2 Interim Actions Completed

The interim remedial actions (MACTEC, 2006b) completed previously included the excavation and off-site disposal of 2,073 tons of impacted soil. The excavated area was about 100 feet (ft) east-west by 40 ft north-south by 10 ft deep. Figure 2-1 shows the area excavated and the sampling locations. Three piezometers and a monitoring well (TP-1, TP-2, B511l, and MW-7S) were removed during the excavation but not replaced. A 4-inch diameter stainless steel well screen was placed in the southeast corner of the excavation to a depth of 11.75 ft to act as a backfill observation well (SWMU17-OB-1).

HRC was added to the floor of the excavation prior to backfilling with clean fill to assist in the bio-dechlorination of the COCs.

2.1.3 Site Stratigraphy and Hydrogeology

Based on approximately 73 soil borings drilled in this sub-area, the stratigraphy of the unconsolidated material above bedrock consists of:

0 to 1.5 ft bgs	Surface cover - asphalt, concrete, gravel, and/or rock base
1 to 17 ft bgs	Fill, clayey silt, silty clay, and organic silt
11 to 49.5 ft bgs	Clay
49.5 to 53.5 ft bgs	Weathered limestone rubble and clay
53.5 to 54 ft bgs	Clay
54 to 75 ft bgs	Clay and weathered shale and gravel

Figure 2-2 shows the historical sampling locations in Sub-area 2B. Figure 2-3 presents a geologic cross-section from west to east through Sub-area 2B (modified after RFI Figure 2-10). The line of section for this cross-section is shown on Figure 2-2 and RFI Figure 2-8 as B to B' (Appendix A). As described in the RFI, both shallow and deep groundwater zones exist in Sub-area 2B, separated by a confining layer. The deep groundwater zone is further defined by intermediate and deep wells/piezometers. The shallow zone monitoring wells have screened intervals ranging from 2.0 to 16.5 ft below ground surface (bgs). Intermediate wells typically have screened intervals ranging from 32 to 42 ft bgs and the deep well (MW-11D) is screened from 64 to 74 ft bgs.

The average depth to shallow groundwater was 5.4 ft bgs and ranged from 3.2 ft bgs to 8.2 ft bgs during four groundwater sampling events from November 2008 to June 2011. The shallow zone groundwater flow direction was generally to the southeast with a gradient of about 0.03 ft/ft (refer to Figure 2-4(a)). From the RFI, assuming a hydraulic conductivity of 3.8×10^{-5} centimeters per second (cm/sec) and a porosity of 10%, the average groundwater seepage velocity is 360 cm/year (11.8 ft/year).

The average water depth in the intermediate wells was 7.5 ft bgs and ranged from 6.2 ft bgs to 12.6 ft bgs with varying flow directions to east and west. In the deep well, MW-11D, the average water depth was 22.2 ft bgs and the deep zone groundwater flow was to the south based on the site-wide deep zone wells (Figure 2-4(b)). The intermediate and deep monitoring wells data was collected during the same sampling events described above for the shallow groundwater.

2.1.4 Soil Concentrations

Table 2-1 lists all the chlorinated solvent soil concentration data available from the portion not removed during the interim action excavation. The soil results indicate there are:

1. Residual localized impacts below the limits of the excavation; and

2. Impacts on the walls of the excavation, i.e. residual soil impacts exist beyond the limits of the excavation.

2.1.5 Groundwater Concentrations

Table 2-2 lists the chlorinated solvent groundwater concentrations from 36 shallow wells, three intermediate wells, one deep well, and one backfill well. The samples were collected from 1998 to 2011. These wells are shown on Figure 2-2.

2.1.6 Evaluation of Groundwater

2.1.6.1 Shallow Groundwater Zone

The extent of higher chlorinated solvent concentrations has been identified and is confined to an area within about 100 ft of the excavated area, as defined by:

Well ID	Currently Present/Absent	Distance/Direction from Excavated Area	# of Times Sampled (years)
B51I1*	absent	within	1 (2005)
MW-6S	present	40 ft/east, down gradient	13 (1998-2011)
MW-7S	absent	within	8 (2001-2005)
MW-8S	present	75 ft/southwest, cross gradient	14 (2001-2011)
MW-9S	present	75 ft/east, down gradient	11 (2001-2008)
SB13*	absent	45 ft/southwest, cross gradient	1 (2000)
SB18*	absent	within	1 (2000)
TP-1*	absent	within	2 (1998-2001)
TP-2*	absent	within	9 (1998-2005)
TP-4	present	25 ft/south; cross to down gradient	10 (1998-2008)
TP-5*	absent	within	4 (2000-2001)
TP-8*	absent	55 ft/south; down gradient	1 (2001)
TP-9*	absent	50 ft/south; down gradient	1 (2001)
TP-10*	absent	45 ft/west; cross to up gradient	1 (2001)
TP-11*	absent	35 ft/east; down gradient	1 (2001)

Well ID	Currently Present/Absent	Distance/Direction from Excavated Area	# of Times Sampled (years)
TP-14*	absent	35 ft/north; cross gradient	1 (2001)
TP-15*	absent	95 ft/southeast, down gradient	1 (2001)
TP-16*	absent	65 ft/east; cross to down gradient	1 (2001)
TP-17*	absent	15 ft/north; up gradient	1 (2001)
TP-18*	absent	10 ft/north, up gradient	1 (2001)
TP-19*	absent	50 ft/northwest, up gradient	1 (2001)
TP-20*	absent	75 ft/south, down gradient	1 (2001)
TP-21*	absent	60 ft/south; down gradient	1 (2001)
TP-22*	absent	60 ft/southwest; cross to down gradient	1 (2001)
TP-23*	absent	75 ft/southwest; cross to up gradient	1(2001)
TP-24*	absent	75 ft/north, up gradient	2 (2001-2004)
TP-25*	absent	40 ft/north, up gradient	1 (2001)

*: Sampling points abandoned.

Groundwater concentrations show a decreasing trend since 2003. Of the above listed groundwater sampling points, only MW-6S, MW-8S, MW-9S, and TP-4 remain within 100 ft of the excavated area. All the other sampling points were removed, some during the excavation.

2.1.6.2 Deep Groundwater Zone

The deep groundwater zone has four monitoring wells in Sub-area 2B (MW-5I, MW-8I, MW-11I, and MW-11D). The intermediate wells identified with "I" are screened in the upper portion of the deep groundwater zone and the deep well (MW-11D) is screened in the lower portion of the deep groundwater zone.

There is an area of higher chlorinated solvent concentrations in the vicinity of monitoring well MW-5I; however, it is limited in extent based on the following:

- MW-5I is located about 10 ft east of the excavated area.
- Both MW-11I and MW-11D located about 210 ft east of the excavated area have been non-detectable during most sampling events since 2001.

Thus, although the spatial extent of the higher chlorinated solvent concentration area is not defined; it is anticipated to be about 40 ft by 40 ft in the area surrounding MW-5I.

2.2 SUB-AREA 6B

2.2.1 Location and Activities

Figure 2-5 shows Sub-area 6B and the location of the monitoring points. This sub-area is used as the scrap metal recycling dock area and has been used for recycling and accumulating scrap metal since 1954. Prior to the 1980s, this sub-area was also used for drum storage. The primary chemicals of concern are chlorinated solvents and their daughter products as follows:

- PCE,
- TCE,
- cis-1,2- DCE,
- trans-1,2-DCE, and
- Vinyl chloride.

Figure 4-5 in the RFI shows the extent of soil impacts identified during the RFI. Figure 4-6 in the RFI shows the extent of groundwater impacts. Figure 4-4 of the RFI indicates the locations of utilities in Sub-area 6B. There is an industrial sewer line in this sub-area that runs north-south just west of MW3A. Copies of these figures are provided in Appendix A.

2.2.2 Interim Actions Completed

Two interim actions were performed in this sub-area consisting of HRC injection and soil excavation.

2.2.2.1 HRC Injection at MW3

A pilot test in Sub-area 6B consisted of the injection of HRC on July 19, 2002 in nine borings around MW3 and follow-up monitoring in MW3, MW3A (25 ft upgradient), and MW3B (25 ft downgradient). The locations of the injection points are shown on Figure 2-5. The monitoring results provided evidence of accelerated reductive dechlorination. The dechlorination process was observed to go to completion with the reduction of TCE to cis-1,2-DCE to vinyl chloride to ethene to ethane through 2003 (MACTEC, 2004a). However, subsequent sampling indicated that cis-1,2-DCE and trans-1,2-DCE concentrations in MW3 have increased and vinyl chloride concentrations in MW3 have remained stable possibly due to insufficient HRC.

2.2.2.2 Soil Excavation

The soil excavation was completed in September 2005 and 56 tons of excavated soils were disposed off-site (MACTEC, 2006a). The excavated area (refer to Figure 2-5), was at the northwest corner of the dock in the area where piezometers RC2 and RC9 were previously located. The excavated area was about 15 ft east-west by 15 ft north-south by 6 ft deep. Five

soil samples were collected for laboratory analysis from the limits of the excavation, one from each wall and one from the floor. The excavation was filled with clean limestone rock and crushed limestone and compacted in lifts. The surface concrete was replaced to match the existing surface.

Piezometers RC13 and RC14 were installed adjacent to the excavation in July 2005 (prior to the excavation activities). RC15 was installed within the excavated area after completion of the excavation activities in September 2005.

2.2.3 Site Stratigraphy and Hydrogeology

Based on the approximately 20 borings, the stratigraphy generally consists of:

1 to 3 ft bgs	Surface cover - asphalt, concrete, gravel base, fill soils, top soil, silt
1 to 49 ft bgs	Silty clay, clay, silt
49 to 55 ft bgs	Clay
55 to 56 ft bgs	Sandy gravel
56 to 68 ft bgs	Silty clay
68 to 69 ft bgs	Sand
69 to 70 ft bgs	Silty Clay
70 to 74 ft bgs	Limestone bedrock

Figure 2-6 presents a geologic cross-section from southwest to northeast through Sub-area 6B. The line of section is shown on Figure 2-5. Like Sub-area 2B (Section 2.1.3), both shallow and deep groundwater zones exist in Sub-area 6B, separated by a confining layer. Details are described in the RFI. The shallow zone monitoring wells have screened intervals ranging from 3 to 24 ft bgs. The deep well (MW9D) was screened from 62 to 72.5 ft bgs prior to abandonment.

The average depth to groundwater was 4.9 ft bgs and ranged from 1.4 ft bgs to 6.5 ft bgs during four groundwater sampling events from November 2008 to June 2011. The flow direction was generally to the east with a gradient of about 0.003 ft/ft (refer to Figure 2-4(a)). From the RFI, assuming a hydraulic conductivity of 3.8×10^{-5} cm/sec and a porosity of 10%, the average groundwater seepage velocity is 36 cm/year (1.2 ft/year).

The average water depth in the deep well (MW9D) was 0.7 ft bgs and ranged from 0.01 ft bgs to 1.1 ft bgs during three RFI groundwater gauging events from August 2002 to March 2003; however, since 2008 this well has been artesian with groundwater flowing from the well when the well cap is removed. MW9D was abandoned in March 2011. No other deep zone wells exist in Sub-area 6B.

2.2.4 Soil Concentrations

Table 2-3 lists all the chlorinated solvent soil concentrations in the portions not excavated. The soil concentrations indicate there are:

- Localized low-level impacts (4.6 micrograms per kilogram (µg/kg) vinyl chloride) below the limits of the excavation, and

- Low-level impacts (<1.2 µg/kg to 36 µg/kg vinyl chloride) in the walls of the excavation.

2.2.5 Groundwater Concentrations

Table 2-4 lists the chlorinated solvent groundwater concentrations from 20 shallow wells and one deep well. The samples were collected from 2000 to 2011. These wells are shown on Figure 2-5.

2.2.5.1 Shallow Groundwater Zone

Since 2008, an increase in the cis-1,2-DCE concentrations has been observed in MW3.

Evaluation of the shallow groundwater zone impacts indicates a localized hot spot in the vicinity of the MW3. This localized hot spot is limited in extent based on the following well results:

Well ID	Currently Present/Absent	Distance/Direction from MW3	# of Times Sampled (years)
MW3	present	within	23 (2000-2010)
MW3A	present	25 ft/west; up gradient	14 (2002-2004)
MW3B	present	25 ft/east, down gradient	15 (2002-2011)
MW9S	present	140 ft/northeast, cross gradient	15 (2000-2011)
RC1*	absent	70 ft/northwest; up gradient	1 (2000)
RC2*	absent	80 ft/north; cross gradient	1 (2000)
RC3*	absent	105 ft/south; cross gradient	1 (2000)
RC4*	absent	185 ft/west-northwest; up gradient	1 (2000)
RC5*	absent	115 ft/southwest, up gradient	1 (2000)
RC6S*	absent	140 ft/south-southeast; cross gradient	1 (2000)
RC6D	present	160 ft/south, cross gradient	6 (2000-2011)
RC7*	absent	80 ft/south, cross gradient	1 (2000)
RC8S*	absent	50 ft/north-northeast; cross to down gradient	1 (2000)

Well ID	Currently Present/Absent	Distance/Direction from MW3	# of Times Sampled (years)
RC8D	present	55 ft/north-northeast; cross to down gradient	6 (2000-2008)
RC9*	absent	85 ft/north, cross gradient	1 (2000)
RC10*	absent	225 ft/west; up gradient	1 (2000)
RC13	present	80 ft/north, cross gradient	4 (2005-2011)
RC14	present	70 ft/north-northwest; cross gradient	4 (2005-2008)
RC15	present	85 ft/north, cross gradient	2 (2005-2006)

*: Sampling points abandoned.

Of the above listed groundwater sampling points, only MW3, MW3A, MW3B, MW9S, RC6D, RC8D, RC13, RC14, and RC15 remain in Sub-area 6B (North). All the other sampling points were removed, some during the excavation.

2.2.5.2 Deep Groundwater Zone

The deep groundwater zone has not been impacted based on the 11 sampling events at MW9D from 2000 to 2003. MW9D was abandoned in March 2011, since it could not be sampled due to artesian conditions since 2008. MW-9D was the only deep zone monitoring well in Sub-area 6B.

ISCO will be tested in three distinct zones: (i) shallow zone at Sub-area 2B, (ii) intermediate/deep zone at Sub-area 2B, and (iii) shallow zone at Sub-area 6B. The boundaries of these three areas may be adjusted depending on results of the direct-push investigation and monitoring well installations as discussed further in the sections below.

This section presents the proposed interim remediation activities in each of the two sub-areas, namely Sub-area 2B and Sub-area 6B. Although the specific details are different in each sub-area, generically the following activities are proposed:

1. A limited direct-push investigation to collect baseline soil and groundwater samples and to confirm the locations for permanent monitoring wells and oxidant injection locations;

2. Installation of additional groundwater monitoring wells;

3. Pilot test subsurface oxidant injection to evaluate distribution of oxidant and its effectiveness;

4. Groundwater and oxidant monitoring;

5. Additional oxidant injections, if appropriate;

6. Reporting and recommendations; and

7. Regulatory and owner interaction.

Each of these activities is described below.

3.1 LIMITED DIRECT-PUSH INVESTIGATION

A limited direct-push investigation will be conducted prior to subsurface injection to collect baseline soil and groundwater samples in both Sub-area 2B and 6B. Data collected will be used to confirm locations for additional monitoring wells (Section 3.2) and oxidant injection (Section 3.3). Baseline data will include the following:

- Groundwater sampling for the site chemicals of concern (COCs) to assess vertical and horizontal extent in the various water-bearing zones;

- Confirm the locations and construction details of planned permanent monitoring wells; and

- Saturated soil testing in each sub-area to indicate soil permanganate demand; results to be used to confirm oxidant dosage and proposed injection volume.

3.1.1 Direct-Push Locations

In Sub-area 2B, initial direct-push borings will be installed to a depth of 25 ft bgs in the vicinity of SWMU-17 and MW-5I to identify the shallow lateral extent of COCs in those areas. A total of eleven proposed direct-push boring locations (DP-1 to DP-11) are shown on the attached Figure 3-1.

In Sub-area 6B, initial direct-push borings will be installed to a depth of 25 ft bgs and laterally at 20 foot intervals surrounding MW-3. Additional direct-push borings have been selected to the north, south, east and west of the former pilot study area to identify the shallow lateral extent of COCs in those areas. A total of eight proposed direct-push boring locations (DP-12 to DP-19) are shown on the attached Figure 3-2.

To prevent contamination from being drawn downward, direct-push borings will not be extended beyond the low permeability clay (aquitard) that separates the shallow and deep groundwater zones at the site. The total number and locations of direct-push borings may be adjusted in the field based on field screening results.

3.1.2 Soil and Groundwater Sampling

As the direct-push borings are advanced, soil samples will be collected from discreet sampling depths that appear to have the greatest impact based on visual observations, odors, and elevated photoionization detector (PID) readings. Within the bounds of the previously excavated area in Sub-area 2B, soil samples need not be collected at depths above 10 ft where backfill of clean crushed limestone rock exists. A minimum of three soil samples from each sub-area will also be selected for analysis of permanganate demand. These locations will be selected based on field observations and/or from within the area where persistent impacts are known. Priority for selecting samples for permanganate demand will be (i) saturated soil; (ii) samples from different soil types, if found, and (iii) from clayey and/or silty soils which would be expected to have higher organic content than gravels or sands. Results will be used to confirm oxidant dosage and volume to be injected, and to provide information as to whether previously applied HRC may impact effectiveness of planned ISCO at each sub-area. All remaining soil samples will be placed on hold in the laboratory until groundwater analytical results are received and it is decided if soil analysis would provide beneficial information.

Grab groundwater samples will be collected through the direct-push boring (using a bailer or peristaltic pump) at the borehole total depth. Groundwater samples will be analyzed for the COCs for each sub-area plus the water quality and ISCO parameters identified in Table 3-1.

3.1.3 Evaluation of Direct Push Investigation Results

Upon completion of limited direct-push investigation activities, field and analytical data will be reviewed. Results will be used to confirm groundwater monitoring well and injection locations and to confirm oxidant dosage and proposed injection volume. Evaluation of data will be shared with MDNR and any modifications made to the scope of work based on these results will be clearly identified.

3.2 GROUNDWATER MONITORING WELL INSTALLATION

New groundwater monitoring wells include shallow, intermediate, and deep screened zones to provide additional coverage for monitoring results of pilot testing and to provide monitoring of intermediate and deep zones for areas where no monitoring wells currently exist.

3.2.1 Monitoring Well Installations

In Sub-area 2B, a total of nine shallow, intermediate, and deep wells are proposed to provide additional information in the upgradient, crossgradient, and downgradient areas, relative to the former excavation area (MW-2B12I/D, MW-2B13I, MW-2B14S/I, MW-2B15I/D, MW-2B16D, and MW-2B17I, as shown on Figure 3-1). In Sub-area 6B, proposed locations include one shallow monitoring well (MW6B01S) hydraulically upgradient of the former pilot study area and one deep monitoring well (MW6B02D) hydraulically downgradient of MW-3 (Figure 3-2). Proposed well construction details are provided in Table 3-2; however, the exact number, location and construction of these wells may be modified, if appropriate, based on results obtained during the limited direct-push investigation described in Section 3.1. No soil samples will be collected from monitoring well boreholes for chemical analysis.

Monitoring wells will be installed by a well driller licensed in the State of Missouri in accordance with the Missouri Water Well Drillers Act, Sections 256.600 to 256.640 RSMo and the Missouri Well Construction Rules (MDNR, 2009). The well driller will complete State-required well certification forms and submit to the State as required by Missouri Water Well Drillers Act, Section 256.614.

Monitoring wells will be allowed to stabilize for a minimum of 24 hours following installation completion before they are developed. Following development, wells will be allowed to stabilize for a minimum of one week before groundwater levels are measured. One round of static water levels from the newly installed monitoring wells and existing monitoring wells and piezometers in each sub-area will be measured prior to conducting the baseline groundwater sampling event as discussed further in Section 3.4.

3.2.2 Evaluation of Groundwater Monitoring Well Installations

Upon completion of monitoring well installation activities and baseline groundwater sampling (see Section 3.4), field and analytical data will be reviewed. Results will be used to confirm injection locations and volumes. Evaluation of data will be shared with MDNR and any modifications made to the scope of work based on these results will be clearly identified.

3.3 PILOT TEST SUBSURFACE INJECTION(S)

The applicability of ISCO as an interim remedial measure will be tested at the site by an initial injection event analogous to a pilot test to evaluate whether trial injections of oxidant can be adequately distributed in target zones and if the oxidant is effective in reducing residual concentrations of chlorinated solvents and their daughter products in Sub-areas 2B and 6B.

Because this proposed ISCO remedial action is not risk-driven, the strategy for applying ISCO at the Tract 1 Site has been modified from the approach specified in typical ISCO guidance documents such as the Interstate Technology & Regulatory Council's (ITRC) "Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater" (ITRC, 2005).

For low permeability soils, our experience is that characterization information such as oxidant demand, may not be particularly definable from laboratory bench testing. We have found that more relevant information is obtained through actual field application. The general strategy for applying ISCO at Sub-areas 2B and 6B is to proceed with initial pilot test injections and closely monitor results to check and re-adjust the plan based on test results.

We recognize that past additions of HRC may affect ISCO effectiveness, which is why we have recommended a flexible approach with trial injections to determine the effectiveness of ISCO in Sub-areas 2B and 6B. The program includes collection of soil samples for permanganate demand analysis from each sub-area. Results will be used, as appropriate, to confirm oxidant dosage and volume to be injected at each proposed direct-push injection location.

Liquid sodium permanganate has been selected for trial ISCO pilot testing for the following reasons (no biological agents will be used):

- Effective for chlorinated ethenes like the target VOCs,
- Can be delivered ready-mixed in liquid form without requiring onsite mixing equipment,
- Provides a reasonable oxidant loading for the desired injection volumes,
- Does not require activation,
- Does not create significant elevated pressures or temperatures that would potentially cause undesired vapor or dissolved phase migration, and
- Can diffuse into low-permeability zones to cause destruction of chlorinated ethenes within the matrix.

When sodium permanganate is injected into the groundwater zone, sodium permanganate disassociates into sodium cations and permanganate anions. From there, the permanganate can completely oxidize organics (specifically for the Tract I Site – PCE, TCE, DCE, and vinyl chloride) to chloride, carbon dioxide, and water. Permanganate can also react with water, but at a slower rate than it oxidizes organics. When reduced contaminants are no longer available to react with permanganate, this slow decomposition process eventually results in depletion of excess permanganate that may remain in the subsurface after injection and treatment. As noted in Table 3-1, manganese will be monitored prior to and following injection to evaluate potential impact of injected materials in the subsurface.

Sodium permanganate will be delivered as a liquid solution, which reduces the amount of handling required and eliminates the need for onsite mixing. A project-specific health and safety plan (HASP) will be prepared by the contractor selected to implement the pilot test. The HASP will document specific health and safety related issues, including proper handling of oxidant, spill prevention and control, personal protective equipment (PPE) requirements and monitoring, as necessary.

The oxidant dosage and injection volume will be confirmed based on data collected during the limited direct-push investigation and groundwater monitoring well installation activities. At that time, a Material Safety Data Sheet (MSDS) for the material to be injected will be obtained from the supplier and provided to the MDNR.

3.3.1 General Design for Initial Injection Event

The general design for the trial pilot testing in each sub-area will include oxidant injections conducted using closely spaced injection points to increase the chances of obtaining a more uniform distribution of oxidant. Three injection points will be triangulated near each identified injection area such that they are approximately 10 to 15 ft away from the centers marked by MW-3 (Sub-area 6B), MW-5I (Sub-area 2B), and near the eastern boundary of the SWMU-17 excavation (Sub-area 2B). Approximate injection point locations are shown on Figures 3-1 and 3-2. The number and location of injection points are dependent upon field observations and may be modified, if appropriate.

Injections will be conducted under pressure (rather than gravity) to facilitate acceptance in the subsurface. Oxidant will be injected to intervals that are 2 ft in length using a direct-push method. Table 3-3 identifies the proposed injection points, injection intervals, and a range of volume per interval and location. The proposed volume of injectant has been estimated based on hydraulics and technical knowledge of in-field applicability, rather than stoichiometric calculations. Volume was estimated as providing a sufficient amount of sodium permanganate to provide benefit in reducing high concentrations but not so much volume that there is risk of creating unnecessarily high injection pressures or risk daylighting or short-circuiting to the surface. The specific process for injecting into the saturated zone will be evaluated by the contractor selected to implement the pilot tests and additional or revised details will be provided to MDNR at that time.

3.3.2 Evaluation of Initial Oxidant Injection

Upon completion of the initial injection event and subsequent oxidant monitoring (discussed further in Section 3.4), field and analytical data will be reviewed to evaluate chemical concentration reductions and confirm injection locations, volumes, and protocol for subsequent injection events, if deemed appropriate. Evaluation of data will be shared with MDNR and any modifications made to the scope of work or recommendations for additional injections will be clearly identified.

3.3.3 Subsequent Injection Events

Pending review and analysis of the initial injection event, additional injection events may be proposed. Injection locations and protocols will be identified and shared with MDNR before implementation.

3.4 GROUNDWATER AND OXIDANT MONITORING PLAN

A monitoring program will be utilized to quantify the effectiveness of the remedial oxidants. Table 3-1 outlines the monitoring program for baseline groundwater sampling (following well installations) and oxidant monitoring (following injections).

To obtain the necessary field and laboratory parameters, all sampling will be conducted by low-flow groundwater sampling. As such, any pre-installed sampling equipment (i.e., snap samplers) will be removed prior to the baseline sampling event.

As discussed in Section 3.3.2, upon completion of the post-injection sampling event(s), data will be reviewed and evaluated to confirm injection locations, volumes, and protocol for subsequent injection events, if deemed appropriate. Evaluation of data will be shared with MDNR and any modifications made to the scope of work will be clearly identified.

3.5 REPORTING AND RECOMMENDATIONS

Six months following the first injection event, a comprehensive evaluation of the data collected will be conducted. A final report will be prepared that summarizes the activities conducted in each sub-area, the evaluation of the monitoring data, and recommendations for further actions, if applicable. The report will include:

- Site plans showing each sub-area, site features, sampling, injection and monitoring points, and vertical profiles;
- Field and analytical data compiled into tables as appropriate;
- Laboratory reports and chain of custody documentation;
- Documentation of waste characterization and off-site disposal, if appropriate;
- Boring, well construction, and well development logs; and
- Field injection logs and field notes documenting quantity of material injected and noted observations regarding each individual injection event.

3.6 REGULATORY AND PROPERTY OWNER INTERACTION

As tasks are completed and additional data is available to support decision making for subsequent tasks, this information will be shared with the regulators. Interactions may include a

combination of conference calls, face to face meetings, site visits, etc. This level of interaction will allow decisions to be made in the field as necessary to optimize the work. Boeing also intends to keep the property owners (i.e. the City of St. Louis and GKN) informed of the activities.

SECTION 4.0
SCHEDULE

The schedule to complete the above tasks is as follows:

- The direct-push investigation will begin within 60 days of receipt of approval from the Agency personnel;
- Installation of monitoring wells and pilot test injections will begin within 60 days of receipt of direct-push investigation laboratory data;
- Groundwater monitoring activities will begin 45 days and repeated after 90 days of the initial injections; and
- Additional injections may be initiated after the evaluation of the groundwater monitoring data collected.

Interstate Technology & Regulatory Council's (ITRC), 2005. *Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater, Second Edition,* January.

MACTEC Engineering and Consulting, Inc. (MACTEC), 2004a. *Enhanced Bioremediation Pilot Test Report for McDonnell Douglas, Hazelwood, Missouri.*

MACTEC, 2004b. *RCRA Facility Investigation Report for McDonnell Douglas, Hazelwood, Missouri*, December.

MACTEC, 2006a. *Interim Action Remedial Excavation Completion Report, Boeing Tract 1, McDonnell Douglas, Hazelwood, Missouri*, May.

MACTEC, 2006b. *Interim Measure Completion Report, Solid Waste Management Unit 17, McDonnell Douglas, Hazelwood, Missouri*, June.

Missouri Department of Natural Resources (MDNR), 2009. *Missouri Well Construction Rules,* Division of Environmental Quality, August.

Risk Assessment & Management Group, Inc. (RAM), 2004. *Risk-Based Corrective Action Report, Boeing Tract 1, St. Louis, Missouri,* September.

RAM Group of Gannett Fleming, Inc. (RAM Group), 2012. *Focused Corrective Measures Study, The Boeing Company Tract 1, Hazelwood, Missouri, MOD000818963*, February.

Table 2-1
Chlorinated Solvent Soil Concentrations for SWMU 17 Area (µg/kg)
Boeing Tract 1, Hazelwood, Missouri

Sample ID	Depth [ft bgs]	Sample Date	Tetrachloro ethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl chloride
Soil Boring Samples							
SB-2	11-12.5	2/4/1998	**1,100**	NA	**46**	<6.4	NA
SB-2	2.3-4.5	2/4/1998	**18,000**	NA	<6.5	<6.5	NA
SB-4	11.5-13.5	2/4/1998	**200,000**	NA	**760**	<7.2	NA
SB-4	14-16	2/4/1998	**240,000**	NA	**11,900**	<19,000	NA
SB-5	14-16	2/4/1998	**3,600**	NA	**280**	<38	NA
SB-5	5.5-7	2/4/1998	**35**	<6.5	<6.5	<6.5	<13
SB-18	15	12/5/2000	**9,300,000**	**14,000**	**68,000**	<5,000	**63**
MW-6S (SB-10)	4-5	4/20/1998	<6.3	**9.3**	<6.3	<6.3	<13
MW-6S (SB-10)	14-15	4/20/1998	<7.4	**28**	<7.4	**24**	<15
MW-7S (SB-14)	14	12/4/2000	NA	NA	NA	NA	NA
TP-1 (SB-1)	12-13	2/4/1998	**9,100**	NA	**22**	<6.4	NA
TP-1 (SB-1)	16-17	2/4/1998	**58,000**	NA	**88**	<6.8	NA
TP-2 (SB-3)	10.5-11.5	2/4/1998	**3,000**	NA	**24**	<6.7	NA
TP-4 (SB-7)	3.5-4.5	2/6/1998	**4,200**	**44**	<6.6	<6.6	<13
TP-4 (SB-7)	7.5-8.5	2/6/1998	**9.7**	<6.4	<6.4	<6.4	<13
TP-5 (SB-11)	5	12/4/2000	**440**	**1,900**	**57,000**	**7,200**	**560**
Excavation Confirmation Samples							
EXC-W-1	8	10/14/2005	**140**	**220**	**410**	**4**	**9.5**
EXC-W-2	7	11/9/2005	**7.5**	**3**	**31**	**1**	**0.65**
EXC-N-2	10	10/14/2005	**3,600**	**50**	**50**	**50**	**50**
EXC-N-3	6	10/14/2005	**15,000**	**400**	**110**	**110**	**110**
EXC-N-4	8	10/14/2005	**590**	**98**	**570**	**25**	**24.5**
EXC-N-05	7	11/9/2005	**3**	**1**	**2**	**1**	**0.65**
EXC-N-06	7	11/9/2005	**36**	**7**	**14**	**1**	**0.65**
EXC-N-07	6	11/14/2005	**8,700**	**160**	**260**	**1**	**7.7**
EXC-E-1	5	11/14/2005	**49**	**49**	**3,100**	**49**	**1,800**
EXC-S-1	2	11/14/2005	**1,350**	**1,350**	**135**	**1,350**	**1,350**
EXC-S-2	5	11/14/2005	**270**	**65**	**230**	**65**	**65**
EXC-S-3	6	11/14/2005	**25**	**25**	**1,300**	**25**	**840**
EXC-S-4	8	11/14/2005	**3,300**	**600**	**2,200**	**100**	**100**

Notes:
ug/kg - micrograms per kilogram
ft bgs: Feet below ground surface
Bold values are detected concentrations
<: less than the reporting limit concentration
NA: Not analyzed

Table 2-2
Chlorinated Solvent Groundwater Data for SWMU 17 Area
Boeing Tract 1, Hazelwood, Missouri

Sample ID	Collected Date	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl chloride
Current Wells						
B48N1	11/11/2002	<5	<5	<5	<5	<5
	12/11/2002	3.4J3	<1	14	<1	<1
	3/21/2003	13	2.8	30	<1	<1
	6/27/2003	27	6.7	59	<1	<1
	11/20/2008	4.1J	<5	28.2	<5	<2
MW-5I	4/22/1998	<5	140,000	5,500	26	250
	2/22/2001	<500	270,000EF	3,500F	<500	<500
	2/22/2001 (DUP)	<1,000	230,000EF	4,600F	<1,000	<1,000
	7/27/2001	<2,000	160,000EFH	2,600FH	<2,000	<2,000
	10/26/2001	<5,000	150,000FH	<5,000	<5,000	<5,000
	12/18/2001	72F	60,000EF	2,100F	<50	170F
	3/7/2002	<1,000	100,000FH	1,900FH	<1,000	<1,000
	5/30/2002	<1,000	130,000EFH	3,500FH	<1,000	1,200FHJ4
	8/8/2002	<10,000	130,000FH	<10,000	<10,000	<10,000
	12/9/2002	<2,000	100,000	2,100	<2,000	<2,000
	3/19/2003	<500	120,000E	3,200	<500	<500
	6/27/2003	72	120,000	3,500	18	180
	6/27/2003 (DUP)	70	110,000	3,600	20	210E
	10/21/2005	200,000E	23,000	25,000E	<500	1,200
	11/20/2008	<250	89,000	4,430	<250	181
	4/29/2010	<10,000	223,000	9,600J	<10,000	<4,000
	11/1/2010	<10,000	263,000	14,500	<10,000	<4,000
	7/13/2011	< 10,000	250,000	13,600	< 10,000	< 4,000
	9/29/2011	< 1,000	214,000	12,700	< 4,000	1,000 J
MW-6S	4/21/1998	<5	370	4,000	55	940
	2/22/2001	<10	120F	32F	<10	53F
	7/27/2001	<1	<1	7.6H	<1	16HJ3
	12/19/2001	<1	<1	6H	<1	7.5H
	3/8/2002	<1	<1	12	<1	19
	5/30/2002	<5	<5	8.5FH	<5	9FH
	6/19/2003	<1	<1	14	1.8J4	29
	10/21/2005	3.1	<1	8	<1.0 J4, J3	17
	11/20/2008	<5	<5	3.8J	<5	<2
	4/29/2010	<5	<5	<5	<5	<2
	10/29/2010	<5	<5	<5	<5	<2
	7/13/2011	< 5	< 5	< 5	< 5	< 2
MW-8S	2/20/2001	4	<1	<1	<1	<1
	7/26/2001	3	<1	<1	<1	<1
	7/26/2001 (Dup)	2	<1	<1	<1	<1
	10/29/2001	6	<1	<1	<1	<1
	10/29/2001 (Dup)	5	<1	<1	<1	<1
	12/13/2001	2.8H	<1	<1	<1	<1
	12/13/2001 (Dup)	3.4H	<1	<1	<1	<1
	3/7/2002	<1	<1	<1	<1	<1
	3/7/2002 (Dup)	3	<1	<1	<1	<1

Table 2-2
Chlorinated Solvent Groundwater Data for SWMU 17 Area
Boeing Tract 1, Hazelwood, Missouri

Sample ID	Collected Date	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl chloride
MW-8S	5/30/2002	5	1.6	1.4	<1	<1
	5/30/2002 (Dup)	4	<1	<1	<1	<1
	8/8/2002	3.3H	<1	<1	<1	<1
	8/8/2002 (Dup)	3	<1	<1	<1	<1
	12/9/2002	<1	<1	<1	<1	<1
	3/18/2003	2	<1	<1	<1	<1
	3/18/2003 (Dup)	2	<1	<1	<1	<1
	6/19/2003	32	1.6J4	2	<1	<1
	11/20/2008	1.9J	<5	<5	<5	<2
	4/29/2010	2J	<5	<5	<5	<2
	10/28/2010	2.3J	<5	<5	<5	<2
	7/13/2011	1.6 J	< 5	< 5	< 5	< 2
MW-8I	2/20/2001	<1	<1	<1	<1	<1
	7/26/2001	<1	<1	<1	<1	<1
	10/26/2001	<1	<2	<1	<1	<1
	12/18/2001	13H	<1	<1	<1	<1
	3/8/2002	<1	<1	<1	<1	<1
	5/30/2002	<1	<1	<1	<1	<1
	8/8/2002	<1	<1	<1	<1	<1
	12/9/2002	<1	8.9	<1	<1	<1
	3/18/2003	<1	<1	<1	<1	<1
	6/26/2003	<1	<1	<1	<1	<1
	11/20/2008	<5	<5	<5	<5	<2
	4/29/2010	<5	<5	<5	<5	<2
	10/28/2010	<5	<5	<5	<5	<2
	7/13/2011	< 5	< 5	< 5	< 5	< 2
MW-9S	2/21/2001	<1	<1	<1	<1	<1
	7/27/2001	<1	1.2H	<1	<1	<1
	7/27/2001 (Dup)	<1	1H	<1	<1	<1
	10/30/2001	<1	<1	1.3H	<1	<1
	10/30/2001 (Dup)	<1	<1	1.3H	<1	<1
	12/19/2001	<50	52F	<50	<50	<50
	12/19/2001 (Dup)	<1	<1	1.4H	<1	<1
	3/5/2002	<1	<1	<1	<1	<1
	5/30/2002	6,900EF	3,800EF	2,400F	<50	55F
	8/8/2002	<25	460F	<25	<25	<25
	12/11/2002	<1	<1	<1	<1	<1
	3/21/2003	<1	<1	<1	<1	<1
	3/21/2003 (Dup)	<1	<1	<1	<1	<1
	6/27/2003	<1	<1	<1	<1	<1
	11/20/2008	<5	<5	<5	<5	<2

Table 2-2
Chlorinated Solvent Groundwater Data for SWMU 17 Area
Boeing Tract 1, Hazelwood, Missouri

Sample ID	Collected Date	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl chloride
MW-9S	3/8/2011	<5	<5	<5	<5	<2
MW-10S	2/20/2001	<1	<1	<1	<1	<1
	7/27/2001	<1	<1	<1	<1	<1
	10/29/2001	<1,000	<1,000	<1,000	<1,000	<1,000
	12/19/2001	<1	<1	<1	<1	<1
	3/5/2002	<5	<5	<5	<5	<5
	6/3/2002	<1	<1	<1	<1	<1
	6/17/2003	<1	<1	<1	<1	<1
	11/19/2008	<5	21.9	<5	<5	<2
MW-11S	2/20/2001	<1	<1	<1	<1	<1
	7/25/2001	29	8.9	19	<1	<1
	10/29/2001	<1	<1	<1	<1	<1
	12/17/2001	<1	<1	<1	<1	<1
	3/5/2002	<1	<1	<1	<1	<1
	6/3/2002	<1	<1	1.5H	<1	<1
	8/13/2002	<1	<1	<1	<1	<1
	12/5/2002	<1	<1	<1	<1	<1
	3/12/2003	<1	<1	<1	<1	<1
	6/17/2003	<1	<1	<1	<1	<1
	11/20/2008	<5	294	7.58	<5	<2
	4/29/2010 (SS)	<5	4.5J	<5	<5	<2
	4/29/2010 (LF)	<5	3.7J	<5	<5	<2
	10/29/2010 (SS)	<5	3.8J	<5	<5	<2
	10/29/2010 (LF)	<5	2.6J	<5	<5	<2
	7/14/2011	< 5	2.2 J	< 5	< 5	< 2
MW-11I	2/19/2001	<1	<1	<1	<1	<1
	7/26/2001	<1	<1	<1	<1	<1
	10/26/2001	<1	<2	<1	<1	<1
	12/17/2001	<1	<1	<1	<1	<1
	3/5/2002	<1	<1	<1	<1	<1
	6/3/2002	<1	<1	<1	<1	<1
	8/13/2002	<1	<1	<1	<1	<1
	8/13/2002 (Dup)	<1	<1	<1	<1	<1
	12/9/2002	<1	12	<1	<1	<1
	3/18/2003	<1	<1	<1	<1	<1
	3/18/2003 (Dup)	<1	<1	<1	<1	<1
	6/25/2003	<1	<1	<1	<1	<1
	6/25/2003 (Dup)	<1	<1	<1	<1	<1
	11/17/2008	<5	<5	<5	<5	<2
	4/28/2010 (SS)	<5	<5	<5	<5	<2
	4/28/2010 (LF)	<5	<5	<5	<5	<2

Table 2-2
Chlorinated Solvent Groundwater Data for SWMU 17 Area
Boeing Tract 1, Hazelwood, Missouri

Sample ID	Collected Date	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl chloride
MW-11I	10/29/2010 (SS)	<5	<5	<5	<5	<2
	10/29/2010 (LF)	<5	<5	<5	<5	<2
	7/14/2011	< 5	< 5	< 5	< 5	< 2
MW-11D	2/19/2001	<1	<1	<1	<1	<1
	7/26/2001	<1	<1	<1	<1	<1
	10/26/2001	<1	17	<1	<1	<1
	12/17/2001	<1	1.3	<1	<1	<1
	3/5/2002	<1	1	<1	<1	<1
	6/3/2002	<1	5.2	<1	<1	<1
	6/3/2002 (Dup)	<1	4.6H	<1	<1	<1
	8/13/2002	<1	1.1	<1	<1	<1
	12/5/2002	<1	<1	<1	<1	<1
	3/12/2003	<1	<1	<1	<1	<1
	6/26/2003 (Dup)	<1	<1	<1	<1	<1
	11/18/2008	<5	<5	<5	<5	<2
	4/28/2010	<5	<5	<5	<5	<2
	10/29/2010	<5	<5	<5	<5	<2
	7/14/2011	< 5	< 5	< 5	< 5	< 2
SWMU17-OB-1	11/19/2008	<5	<5	<5	2.3J	<2
	4/29/2010	<5	<5	1.1J	<5	1.2J
	11/1/2010 (SS)	<5	<5	<5	<5	<2
	11/1/2010 (LF)	<5	<5	16.7	<5	24.7
	7/13/2011	< 5	< 5	5.3	< 5	3.3
TP-3	2/6/1998	<5	<5	<5	<5	<10
	2/23/2001	<100	<100	<100	<100	<100
	7/25/2001	<1	<1	<1	<1	<1
	10/29/2001	<1	<1	<1	<1	<1
	12/19/2001	<1	<1	<1	<1	<1
	3/5/2002	<1	<1	<1	<1	<1
	5/30/2002	7,100EF	4,800F	1,900F	<100	<100
	8/8/2002	<200	5,300F	<200	<200	<200
	12/9/2002	<1	<1	<1	<1	<1
	3/19/2003	<1	<1	<1	<1	<1
	6/27/2003	<1	<1	<1	<1	<1
	11/19/2008	<5	<5	<5	<5	<2
	7/12/2011	< 5	< 5	< 5	< 5	< 2
TP-4	2/9/1998	17,000	150	59	6.3	<10
	9-Feb-98 (Dup)	11,000	150	58	5.8	<10
	2/21/2001	79E	8.7	5.6	1.4	2
	7/26/2001	79EH	6.7H	8.6H	<1	1.3H
	10/30/2001	150EFH	33FH	100EFH	<2	5FH
	12/18/2001	35H	10H	14H	<1	5.2H
	3/8/2002	42J3	7.2	19	<1	6.4
	5/30/2002	320EFH	43FH	86FH	<5	6.2FHJ4

Table 2-2
Chlorinated Solvent Groundwater Data for SWMU 17 Area
Boeing Tract 1, Hazelwood, Missouri

Sample ID	Collected Date	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl chloride
TP-4	6/26/2003	2,700E	160	190	1.1	5.3
	10/21/2005	2,100E	470E	1,200E	7.6	140
	11/19/2008	111	16.3	77.5	<5	3.87
	7/12/2011	85.9	23.7	109	1.8 J	4.5
	7/12/2011-Dup	115	27.3	115	1.8 J	4.7
TP-6	9/5/2001	<1,000	<1,000	<1,000	<1,000	<1,000
	12/18/2001	<100	2,900F	<100	<100	<100
	3/5/2002	<1	<1	<1	<1	<1
	3/5/2002 (Dup)	<1	<1	<1	<1	<1
	6/3/2002	<1	1.9H	<1	<1	<1
	8/13/2002	<1	<1	<1	<1	<1
	12/5/2002	<1	<1	<1	<1	<1
	3/18/2003	<1	<1	<1	<1	<1
	6/17/2003	<1	<1	<1	<1	<1
	11/19/2008	<5	<5	<5	<5	<2
	11/19/2008 (Dup)	<5	<5	<5	<5	<2
	7/12/2011	< 5	< 5	< 5	< 5	< 2
Abandoned Wells						
B48I1	11/11/2002	<5	<5	<5	<5	<5
B48I2	11/11/2002	<5	<5	<5	<5	<5
B51I1	10/21/2005	4.1	1.5	160E	1.6	9.9
MW-7S	2/22/2001	130,000EF	10,000F	5,800F	<500	<500
	7/27/2001	66,000FH	<10,000	<10,000	<10,000	<10,000
	10/30/2001	490,000EFH	72,000FH	36,000FH	<2,000	<2,000
	12/13/2001	64,000EFH	5,800FH	9,400FH	<1,000	<1,000
	3/5/2002	49,000EFHJ3	5,500FH	4,100FH	<250	<250
	5/30/2002	65,000EF	5,100F	4,500F	<1,000	<1,000
	6/19/2003	89,000E	6,200	4,000	<500	<500
	10/21/2005	82,000E	4,700	4,800	<500J4J3	<500
SB18	12/5/2000	86,000	920J	2,400J	<2,500	<5,000
TP-1	2/5/1998	210,000	<25,000	97,000	150	<50,000
	2/23/2001	110,000EF	4,200F	58,000EF	<1,000	<1,000
TP-2	2/6/1998	45,000	6,000	6,900	30	<10
TP-2	2/23/2001	<1	<1	<1	<1	<1
	7/25/2001	12,000FHJ3	3,200FH	4,100FH	<250	<250
	10/30/2001	12,000FH	4,200FH	5,800FH	<1,000	<1,000
	12/18/2001	17,000EFH	3,800EFH	6,400EFH	<50	70FH
	3/8/2002	16,000FH	4,100FH	7,100FH	<1,000	<1,000
	5/30/2002	25,000EFH	5,600FH	11,000FH	<500	<500
	6/26/2003	25,000	6,000J4	8,700	<500	<500
	10/21/2005	24,000	3,800	5,500	<100	140
TP-5	12/4/2000	54,000	4,600	3,300	<2,500	<5,000

Table 2-2
Chlorinated Solvent Groundwater Data for SWMU 17 Area
Boeing Tract 1, Hazelwood, Missouri

Sample ID	Collected Date	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl chloride
TP-5	2/23/2001	44,000F	4,400F	5,700F	<2,500	<2,500
	7/27/2001	31,000FH	5,900FH	4,600FH	<1,000	<1,000
	10/30/2001	400,000EFH	84,000FH	67,000FH	<2,000	4,400FH
TP-7	9/5/2001	<5,000	<1,000	<1,000	<1,000	<3,000
TP-8	9/5/2001	<5	<1	200E	<1	<3
TP-9	9/5/2001	<2,500	<500	<500	<500	<1500
TP-10	9/5/2001	<1,200	<250	2,700FH	1,100FH	<750
TP-11	9/5/2001	4,300F	860FJ4	9,300F	<250	1,600F
TP-12	9/5/2001	<5	<1	<1	<1	<3
TP-13	9/5/2001	<5	<1	<1	<1	<3
TP-14	9/6/2001	<2,500	<500	<500	<500	<1,500
TP-15	9/6/2001	<25,000	<5,000	<5,000	<5,000	<15,000
TP-16	9/6/2001	<250	<50	<50	<50	<150
TP-17	9/6/2001	270F	15F	73F	<10	<10
	9/6/2001 (Dup)	190F	<10	66F	<10	<10
TP-18	9/6/2001	<1	<1	12	1.6	1
TP-19	9/6/2001	<5	<1	3.6	1.3	<3
	9/6/2001 (Dup)	<5	<1	3.5	1.4	<3
TP-20	10/15/2001	<5		<5	<5	< 5
	10/15/2001 (Dup)	<5	<1	<1	<1	<3
TP-21	10/15/2001	<5		155.6	<5	<5
	10/15/2001 (Dup)	<5		140.3	<5	<5
TP-22	10/15/2001	<5		581.2	139.9	<5
TP-23	10/15/2001	9.6		<5	<5	195.8
TP-24	10/15/2001	<5	<1	<1	<1	<3
	10/15/2001 (Dup)	<5	<1	<1	<1	<3
TP-25	10/15/2001	<5	<1	3.1	<1	<3

Notes:
All concentrations in ug/L (micrograms per liter).
E: GTL (EPA) - Greater than upper calibration limit: Actual value is known to be greater than the upper calibration range.
F: The original sample was diluted due to high amount of the analyte.
H: Re-analyzed.
J: analyte detected below reporting limit and estimated value shown.
J3: The associated batch QC was outside the established quality control range for precision.
J4: The associated batch QC was outside the established quality control range for accuracy.
S: spike recovery outside accepted recovery limits.
SS: Snap sample.
LF: Low-flow sample.

Table 2-3
Soil Data for Sub-Area 6B (North)
Boeing Tract 1, Hazelwood, Missouri

Sample ID	Date	Depth (ft bgs)	Tetrachloro ethene	Trichloro ethene	1,2-Dichloro ethene (Total)	cis-1,2-Dichloro ethene	trans-1,2-Dichloro ethene	Vinyl chloride
MW-3-12	7/19/2000	12	< 6.3	1.9J	250			< 6.3
MW9S-12	9/18/2000	12	< 6.4	< 6.4		< 3.2	< 3.2	< 6.4
MW9S-18		18	< 5	< 5		< 5	< 5	< 5
MW9S-23		23	< 5	< 5		< 5	< 5	< 5
MW9S-37		37	< 5	< 5		< 5	< 5	< 5
MW9S-55		55	< 5	< 5		< 5	< 5	< 5
MW9S-68		68	< 5	< 5		< 5	< 5	< 5
MW9S-9		9	< 5	< 5		< 5	< 5	< 5
RC10-10	11/13/2000	10	< 6.2	< 6.2		< 3.1	< 3.1	< 6.2
RC11-15	12/7/2000	15	< 5	< 5		< 5	< 5	< 10
RC12-15		15	< 5	< 5		< 5	< 5	< 10
RC1-7	7/25/2000	7	< 6.5	3.9J	58			51
RC2-7		7	< 6.4	< 6.4	< 6.4			4.7J
RC3-5		5	< 7.9	98	240			< 7.9
RC3-5 DUP		5	< 6.9	120D	180D			< 6.9
RC4-10	9/18/2000	10	< 6.3	24		9.1	< 3.2	< 6.3
RC5-9		9	< 6.4	< 6.4		< 3.2	< 3.2	< 6.4
RC6-20		20	< 6.1	< 6.1		< 3.1	< 3.1	< 6.1
RC6-7		7	< 6.3	58		44	< 3.2	28
RC7-16		16		< 5		< 5	< 5	< 5
RC8-25		25	< 6.3	< 6.3		< 3.1	< 3.1	< 6.3
RC8-8		8					< 5	< 5
RC9-8	11/13/2000	8	< 6.4	< 6.4		< 3.2	< 3.2	< 6.4
REC-EXC-F-6	9/8/2005	6						4.6
REC-EXC-N-5		5						<1.2
REC-EXC-S-4		4						17
REC-EXC-E-2		2						<1.2
REC-EXC-W-5		5						36

Notes:
All concentrations in ug/kg (micrograms per kilogram)
< Less than reporting limit shown
Blanks: Not analyzed
ft bgs: Feet below ground surface

Table 2-4
Chlorinated Solvent Groundwater Data for Sub-Area 6B (North)
Boeing Tract 1, Hazelwood, Missouri

Sample ID	Collected Date	Tetrachloro ethylene	Trichloro ethylene	cis-1,2-Dichloro ethylene	trans-1,2-Dichloro ethylene	Vinyl chloride
Current Wells						
MW3	7/28/2000	< 1	1700 D			32
	7/28/2000 (Dup)	< 1	5400 D			30
	1/10/2001	< 5	6900	6000	91	120
	5/9/2001	< 100	3500 FH	2600 FH	< 100	< 100
	5/9/2001 (Dup)	< 100	3800 F	2700 E	< 100	< 100
	7/24/2001	< 1	2700 E	2600 E	62 E	81 E
	7/24/2001 (Dup)	< 1	3900 E	2700 E	62 E	84 E
	10/25/2001	< 25	8000 EF	7600 EF	260 F	130 F
	10/25/2001 (Dup)	< 25	5100 EF	4500 E	130 F	79 E
	3/6/2002	< 1	1400 E	1800 E	67 E	75 E
	3/6/2002 (Dup)	< 1	1100 E	1400 E	62 F	60 E
	6/19/2002	< 100	3900 FH	3300 FH	< 100	< 100
	7/18/2002	< 50	210 FH	3800 FH	73 FH	< 50
	8/15/2002	< 50	51 F	4900 EF	110 F	84 F
	8/15/2002 (Dup)	< 50	83 F	6200 EF	120 F	83 F
	9/23/2002	< 1	8	1300 E	34	440 E
	10/15/2002	< 5	< 5	2200 E	44	1400 E
	11/22/2002	< 25	33	2100 E	39	1100
	12/16/2002	< 5	5.8	1600 E	47	1300E
	1/20/2003	< 1	5.2 J4	2300 E	54	1600E
	2/20/2003	< 1	9.7	2700 E	59	2700E
	3/17/2003	< 1	6.4	2700 E	53	2100E
	4/17/2003	< 50	< 50	2900	< 50	1600
	5/19/2003	< 5	9.1	3600 E	77	1400 E
	6/18/2003	< 1	7.3	4100	68	1000
	1/14/2004	<1	34	2600	100	1000
	11/21/2008	< 5	13.8	16600	190 J	789
	4/29/2010 - SS	< 1000	< 1000	14000	< 1000	1080
	4/29/2010 - LF	< 500	< 500	12800	150 J	953
	11/2/2010 - SS	< 500	< 500	10400	120 J	917
	11/2/2010 - LF	< 500	< 500	16500	180 J	1130
	7/11/2011	< 5000	< 5000	7770	< 5000	< 2000
MW3A	6/18/2002	< 1	190 E	160 E	9.8	4.9
	7/18/2002	< 1	220 E	240 E	12	5.9
	8/15/2002	< 1	240 EJ6	270 EJ6	14	5.3
	9/23/2002	< 1	150 EV	200 EV	12	4.8
	10/15/2002	< 5	170	260 E	10	6
	11/22/2002	< 1	190 E	290 E	12	7.5

Table 2-4
Chlorinated Solvent Groundwater Data for Sub-Area 6B (North)
Boeing Tract 1, Hazelwood, Missouri

Sample ID	Collected Date	Tetrachloro ethylene	Trichloro ethylene	cis-1,2-Dichloro ethylene	trans-1,2-Dichloro ethylene	Vinyl chloride
MW3A	12/16/2002	< 10	230	320	14	< 10
	1/20/2003	< 1	240 EJ4	340 E	17	6.7
	2/20/2003	< 1	220 E	290 E	12	9.3
	3/17/2003	< 1	220 E	270 E	14	7.1
	4/17/2003	< 1	150	220 E	11	8.9
	5/19/2003	< 1	220 E	320 E	18	8.7
	6/18/2003	< 1	260 E	360 E	18	9.9
	1/14/2004	<1	290	460	<1	13
	7/11/2011	< 250	56 J	293	< 250	< 100
MW3B	6/18/2002	< 1	8.5	130 E	2.7	1.2
	7/18/2002	< 1	2.1	100 E	1.7	< 1
	8/15/2002	< 2	< 2	86 FH	< 2	< 2
	9/19/2002	< 1	< 1	65 E	1.5	2.5
	10/15/2002	< 1	< 1	53 E	1.5	15
	11/22/2002	< 1	1.1	30	1.4	15
	12/16/2002	< 1	< 1	27	1.4	11
	1/20/2003	< 1	< 1	27	1.5	15
	2/20/2003	< 1	< 1	19	< 1	12
	3/17/2003	< 1	< 1	15 J6	1.1	7.7
	4/17/2003	< 1	< 1	13	< 1	6.4
	5/19/2003	< 1	< 1	16	< 1	5.8
	6/18/2003	< 1	< 1	16	1.1	4.2
	1/14/2004	<1	<1	6.2	<1	1.8
	7/13/2011	< 5	< 5	43.7	< 5	2.96
MW9S	9/28/2000	< 5	< 5	< 2.5	< 2.5	< 5
	1/8/2001	< 5	< 5	< 5	< 5	< 10
	5/8/2001	< 1	< 1	< 1	< 1	< 1
	7/23/2001	< 1	< 1	< 1	< 1	< 1
	10/23/2001	< 1	< 1	< 1	< 1	< 1
	3/7/2002	< 1	< 1	< 1	< 1	< 1
	6/4/2002	< 1	< 1	< 1	< 1	< 1
	8/12/2002	< 1	< 1	< 1	< 1	< 1
	12/3/2002	< 1	< 1	< 1	< 1	< 1
	3/20/2003	< 1	< 1	< 1	< 1	< 1
	6/23/2003	< 1	< 1	< 1	< 1	< 1
	11/21/2008	< 5	< 5	< 5	< 5	< 2
	4/29/2010	< 5	< 5	< 5	< 5	< 2
	11/3/2010	< 5	< 5	< 5	< 5	< 2

Table 2-4
Chlorinated Solvent Groundwater Data for Sub-Area 6B (North)
Boeing Tract 1, Hazelwood, Missouri

Sample ID	Collected Date	Tetrachloro ethylene	Trichloro ethylene	cis-1,2-Dichloro ethylene	trans-1,2-Dichloro ethylene	Vinyl chloride
MW9S	11/3/2010 (Dup)	< 5	< 5	< 5	< 5	< 2
	7/13/2011	< 5	< 5	< 5	< 5	< 2
RC6D	9/19/2000	< 5	< 5	20	< 2.5	< 5
	8/15/2002	< 1	< 1	4.8	1.9	7.9
	12/16/2002	< 1	< 1	1.7	1.2	2.2
	3/21/2003	< 1	< 1	1.2	2.2	2.8
	6/23/2003	< 1	< 1	< 1	1.2	< 1
	7/13/2011	< 5	< 5	< 5	< 5	< 2
RC8D	9/19/2000	< 5	< 5	14	< 2.5	< 5
	8/15/2002	< 1	4.1	17	1.2	< 1
	12/16/2002	< 1	5.9	12	< 1	< 1
	3/21/2003	< 1	9.7 J4	13	< 1	< 1
	6/24/2003	< 1	13	17	< 1	< 1
	11/21/2008	< 5	11.3	29.3	1.6 J	< 2
	7/14/2011	< 5	19.8	49.8	3.4 J	< 2
RC13	7/29/2005	<1	<1	3.7	<1	4.7
	9/29/2005	<1	<1	12	<1	17
	4/5/2006	<1	<1	3	<1	<1
	7/14/2011	< 5	< 5	3 J	< 5	9.45
RC14	7/29/2005	<1	33	1800	7.6	220
	9/29/2005	<1	51 E	1400 E	16	390 E
	4/5/2006	<1	33	1100 E	11	280 E
	11/21/2008	< 10	3 J	210	3.9 J	198
	7/14/2011	< 5	< 5	72.8	2.4 J	128
RC15	9/29/2005	<1	<1	4.1	<1	1.9
	4/5/2006	<1	<1	6.5	<1	<1
Abandoned Wells						
MW9D	9/28/2000	< 5	< 5	< 2.5	< 2.5	< 5
	1/12/2001	< 5	< 5	< 5	< 5	< 10
	1/12/2001 (Dup)	< 5	< 5	< 5	< 5	< 10
	5/8/2001	< 1	< 1	< 1	< 1	< 1
	7/23/2001	< 1	< 1	< 1	< 1	< 1
	10/23/2001	< 1	< 1	< 1	< 1	< 1
	3/7/2002	< 1	< 1	< 1	< 1	< 1
	5/29/2002	< 1	< 1	< 1	< 1	< 1
	8/12/2002	< 1	< 1	< 1	< 1	< 1
	12/11/2002	< 1	< 1	< 1	< 1	< 1
	12/11/2002 (Dup)	< 1	< 1	< 1	< 1	< 1
	3/14/2003	< 1	< 1	< 1	< 1	< 1

Table 2-4
Chlorinated Solvent Groundwater Data for Sub-Area 6B (North)
Boeing Tract 1, Hazelwood, Missouri

Sample ID	Collected Date	Tetrachloro ethylene	Trichloro ethylene	cis-1,2-Dichloro ethylene	trans-1,2-Dichloro ethylene	Vinyl chloride
MW9D	6/23/2003	< 1	< 1	< 1	< 1	< 1
RC1	7/25/2000	< 10	80			20
RC2	7/25/2000	< 1	< 1			21 D
	4/29/2004					
	7/25/2000					
RC3	7/25/2000	< 1	2.7			16
	7/25/2000 (Dup)	< 1	0.37 J			17
RC4	9/19/2000	< 5	49	9.9	< 2.5	13
RC5	9/18/2000	< 5	< 5	< 2.5	< 2.5	< 5
RC6S	9/18/2000	< 5	120	120	9.1	59
RC7	9/18/2000	< 5	< 5	< 2.5	< 2.5	< 5
RC8S	9/19/2000	< 250	< 250	1600	130	< 250
RC9	11/15/2000	< 5	< 5	< 2.5	< 2.5	< 5
RC10	11/14/2000	< 5	36	11	< 2.5	< 5
RC11	12/7/2000	< 5	< 5	< 5	< 5	< 10

Notes:

All concentrations in ug/L (micrograms per liter).

D: Diluted. The original sample was diluted due to hugh amounts of one or more target analytes. Analytes will be subject to elevated detection limits relative to the dilution factor.

E: GTL (EPA) - Greater than upper calibration limit: Actual value is known to be greater than the upper calibration range.

F: The original sample was diluted due to high amount of the analyte.

H: Re-analyzed.

J: analyte detected below reporting limit and estimated value shown.

J3: The associated batch QC was outside the established quality control range for precision.

J4: The associated batch QC was outside the established quality control range for accuracy.

J6: The sample matrix interfered with the ability to make any accurate determination; spike value is low

S: spike recovery outside accepted recovery limits.

V: Sample concentration was too high to evaluate spike recoveries

SS: Snap sample.

LF: Low-flow sample.

Table 3-1
Baseline Groundwater and Oxidant Monitoring Plan
Boeing Tract 1, Hazelwood, Missouri

Sub-Area		Field Measurements		Laboratory Analysis [a]		
Monitoring Well [d]		Water Quality Parameters [b]	Oxidant (Visual)	VOCs	TPH-GRO, -DRO, -ORO	ISCO Parameters [c]
2B	MW-5I	B, 45, 90	45, 90	B, 45, 90	-	-
	MW-6S	B, 45, 90	45, 90	B, 45, 90	-	-
	TP-4	B, 45, 90	45, 90	B, 45, 90	-	-
	SWMU17-OB-1	B, 45, 90	45, 90	B, 45, 90	-	-
	MW-9S	B, 45, 90	45, 90	B, 45, 90	-	-
	MW-2B12I	B, 45, 90	45, 90	B, 45, 90	-	-
	MW-2B12D	B, 45, 90	45, 90	B, 45, 90	-	-
	MW-2B13I	B, 45, 90	45, 90	B, 45, 90	-	-
	MW-2B14S	B, 45, 90	45, 90	B, 45, 90	-	B, 45, 90
	MW-2B14I	B, 45, 90	45, 90	B, 45, 90	-	B, 45, 90
	MW-2B15I	B, 45, 90	45, 90	B, 45, 90	-	B, 45, 90
	MW-2B15D	B, 45, 90	45, 90	B, 45, 90	-	B, 45, 90
	MW-2B16D	B, 45, 90	45, 90	B, 45, 90	-	B, 45, 90
	MW-2B17I	B, 45, 90	45, 90	B, 45, 90	-	-
6B	MW3	B, 45, 90	45, 90	B, 45, 90	B, 45, 90	B, 45, 90
	MW3A	B, 45, 90	45, 90	B, 45, 90	B, 45, 90	B, 45, 90
	MW3B	B, 45, 90	45, 90	B, 45, 90	B, 45, 90	B, 45, 90
	MW6B01S	B, 45, 90	45, 90	B, 45, 90	-	-
	MW6B02D	B, 45, 90	45, 90	B, 45, 90	-	-

Notes:

[a] For consistency with data sets, suite lists to be analyzed for shall mirror those to be used for MNA monitoring per CMS (RAM, 2012).

[b] Water quality parameters to include dissolved oxygen, pH, oxidation reduction potential, specific conductance, temperature, and alkalinity.

[c] ISCO parameters to include chloride, total & dissolved manganese, and total & dissolved iron. Additionally, ethane, ethane, methane, and carbon dioxide will be analyzed to monitor for the lingering effects of the HRC injections and the impact of permanganate. Dissolved samples are to be field filtered.

[d] The number and location of monitoring wells selected for baseline and/or oxidant monitoring may be adjusted based on results of direct-push investigation, monitoring well installations, and/or injection activities.

45 - 45 days after first injection event
90 - 90 days after first injection event
B - Baseline sampling event
DRO - Diesel Range Organics
GRO - Gasoline Range Organics
ISCO - In-situ chemical oxidation
ORO - Oil Range Organics
TPH - Total Petroleum Hydrocarbons
VOCs - Volatile organic compounds

Analytical Methods

VOCs, TPH-GRO:	SW-846 8260
TPH-DRO, TPH-ORO:	SW-846 8270
Chloride:	EPA 300.0
Total & Dissolved Manganese:	SW-6010B
Total & Dissolved Iron:	SW-6010B
Ethane, Ethene, Methane:	RSK-175
Carbon Dioxide:	RSK-175

Table 3-2
Proposed Monitoring Well Construction Details
Boeing Tract 1, Hazelwood, Missouri

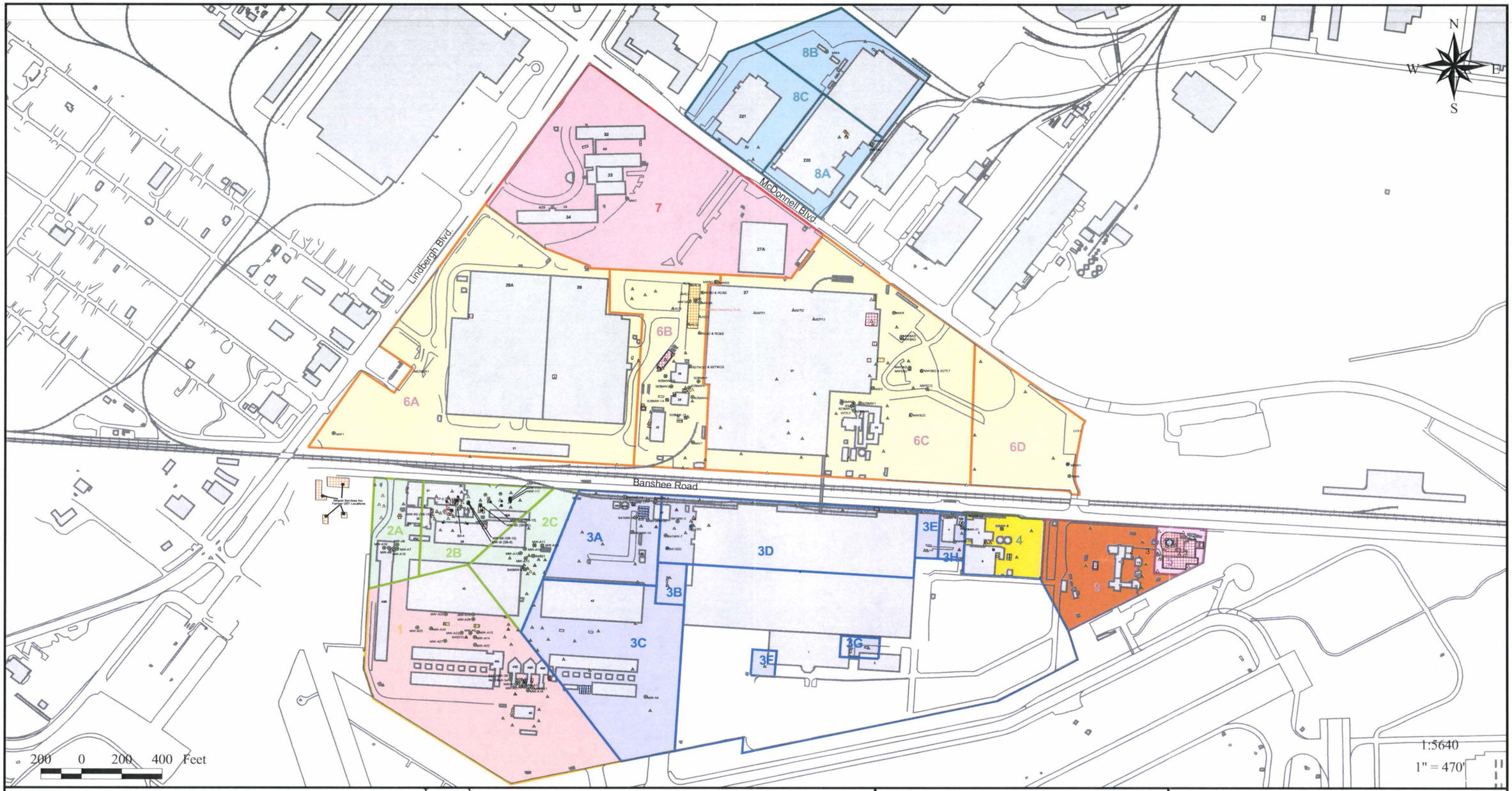
General		Borehole [a]		Casing [a]			Well [a]						Rationale
Sub-Area	Identifier	Diameter (inches)	Interval [b] (feet bgs)	Diameter (inches)	Interval [b] (feet bgs)	Material	Total Depth [b] (feet)	Screened Geology	Screened Interval [b] (feet bgs)	Filter Pack (feet bgs)	Seal (feet bgs)	Cement (feet bgs)	
2B	MW-2B12I	6.25	0-42	2	0-32	Schedule 40 PVC	42	Clay	32-42	30-42	28-30	2-28	* Intermediate, upgradient of former excavation (source area)
	MW-2B12D	6.25	0-75	2	0-65	Schedule 40 PVC	75	Clay, Weathered Shale	65-75	63-75	61-63	2-61	* Deep, upgradient of former excavation (source area)
	MW-2B13I	6.25	0-42	2	0-32	Schedule 40 PVC	42	Clay	32-42	30-42	28-30	2-28	* Intermediate, upgradient of MW-5I (TCE hotspot)
	MW-2B14S	6.25	0-20	2	0-10	Schedule 40 PVC	20	Silty Clay, Clay	10-20	8-20	6-8	2-6	* Shallow, downgradient of former excavation (source area)
	MW-2B14I	6.25	0-42	2	0-32	Schedule 40 PVC	42	Clay	32-42	30-42	28-30	2-28	* Intermediate, downgradient of former excavation (source area)
	MW-2B15I	6.25	0-42	2	0-32	Schedule 40 PVC	42	Clay	32-42	30-42	28-30	2-28	* Intermediate, downgradient of MW-5I (TCE hotspot)
	MW-2B15D	6.25	0-75	2	0-65	Schedule 40 PVC	75	Clay, Weathered Shale	65-75	63-75	61-63	2-61	* Deep, downgradient of MW-5I (TCE hotspot)
	MW-2B16D	6.25	0-75	2	0-65	Schedule 40 PVC	75	Clay, Weathered Shale	65-75	63-75	61-63	2-61	* Deep, vertically downgradient near MW-5I (TCE hotspot)
	MW-2B17I	6.25	0-42	2	0-32	Schedule 40 PVC	42	Clay	32-42	30-42	28-30	2-28	* Intermediate, crossgradient of former excavation (source area)
6B	MW6B01S	6.25	0-20	2	0-10	Schedule 40 PVC	20	Silty Clay, Clay, Silt	10-20	8-20	6-8	2-6	* Shallow, upgradient to former pilot study area
	MW6B02D	6.25	0-75	2	0-65	Schedule 40 PVC	75	Silty Clay, Sand	65-75	63-75	61-63	2-61	* Deep, vertically downgradient near MW-3B

Notes:
[a] Wells to be constructed per MDNR Publication 2175, Missouri Well Construction Rules, dated August 2009. Proposed construction details may be altered based on findings during limited geoprobe investigation to ensure wells are
[b] Final depths and screen intervals will be determined during borehole advancement to ensure that wells are appropriately screened in the shallow, intermediate, and deep zones.

Table 3-3
Proposed Injection Point Details
Boeing Tract 1, Hazelwood, Missouri

Sub-Area	Identifier	Injection Point Total Depth	Injection Intervals	Volume of Oxidant to be Injected [a]	Estimated Volume Range per Injection Point Location
2B	IP-1	42	32-34, 34-36, 36-38, 38-40, and 40-42	~30-80 gallons per 2-foot injection interval	150-400 gallons
	IP-2	42	32-34, 34-36, 36-38, 38-40, and 40-42	~30-80 gallons per 2-foot injection interval	150-400 gallons
	IP-3	42	32-34, 34-36, 36-38, 38-40, and 40-42	~30-80 gallons per 2-foot injection interval	150-400 gallons
	IP-4	15	5-7, 7-9, 9-11, 11-13, and 13-15	~30-80 gallons per 2-foot injection interval	150-400 gallons
	IP-5	15	11-13 and 13-15 [b]	~30-80 gallons per 2-foot injection interval	150-400 gallons
	IP-6	15	5-7, 7-9, 9-11, 11-13, and 13-15	~30-80 gallons per 2-foot injection interval	150-400 gallons
6B	IP7	20	10-12, 12-14, 14-16, 16-18, and 18-20	~30-80 gallons per 2-foot injection interval	150-400 gallons
	IP8	20	10-12, 12-14, 14-16, 16-18, and 18-20	~30-80 gallons per 2-foot injection interval	150-400 gallons
	IP9	20	10-12, 12-14, 14-16, 16-18, and 18-20	~30-80 gallons per 2-foot injection interval	150-400 gallons

Notes:
[a] Volume of oxidant to be injected per interval will be further evaluated and recommended by the contractor selected to implement the scope of work and as
[b] Injection Point (IP-5) is located within the previously excavated area near SWMU-17; no injections will be required above 10 feet in this area.



Legend

- Abandoned Shallow Piezometer
- Abandoned Shallow Well
- Deep Piezometer
- Deep Well
- Intermediate Well
- Other Shallow Boring
- RFA Boring
- RCRA Closure Shallow Boring
- RFI Deep Boring/Temp. Piezometer
- RFI Shallow Boring
- RFI Shallow Boring/Temp. Piezometer
- Shallow Piezometer
- Shallow Well
- UST Closure Sample
- Other Area
- UST
- SWMU

Drawn by: BSM Approved by:

Checked by: Date: September 10, 2004

Risk Assessment & Management Group, Inc.

Figure 1-1
Risk Assessment Exposure Area Map, Boeing Tract 1 (North and South)

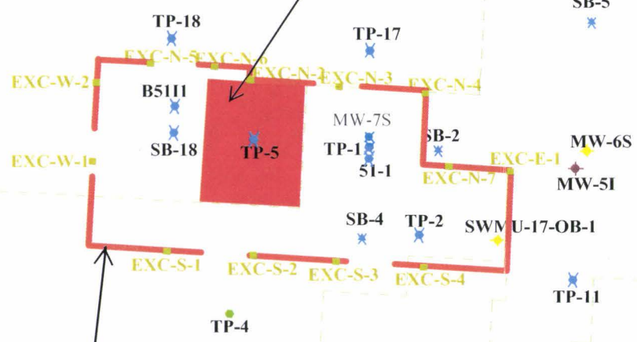
P:\1_Gis\3250035046\apr\risk\risk_fig1-1_040910.apr

Banshee Road

N

SWMU 17

Former Building 51



Limits of Excavation

Former Building 52

Building 48

LEGEND

- MONITORING WELL (SHALLOW & BACKFILL)
- MONITORING WELL (INTERMEDIATE)
- ABANDONED MONITORING WELL (SHALLOW)
- ABANDONED/EXCAVATED BORING
- PIEZOMETER
- ABANDONED/EXCAVATED PIEZOMETER
- EXCAVATION CONFIRMATION SAMPLING LOCATIONS
- FORMER BUILDING OUTLINE
- CURRENT BUILDING OUTLINE

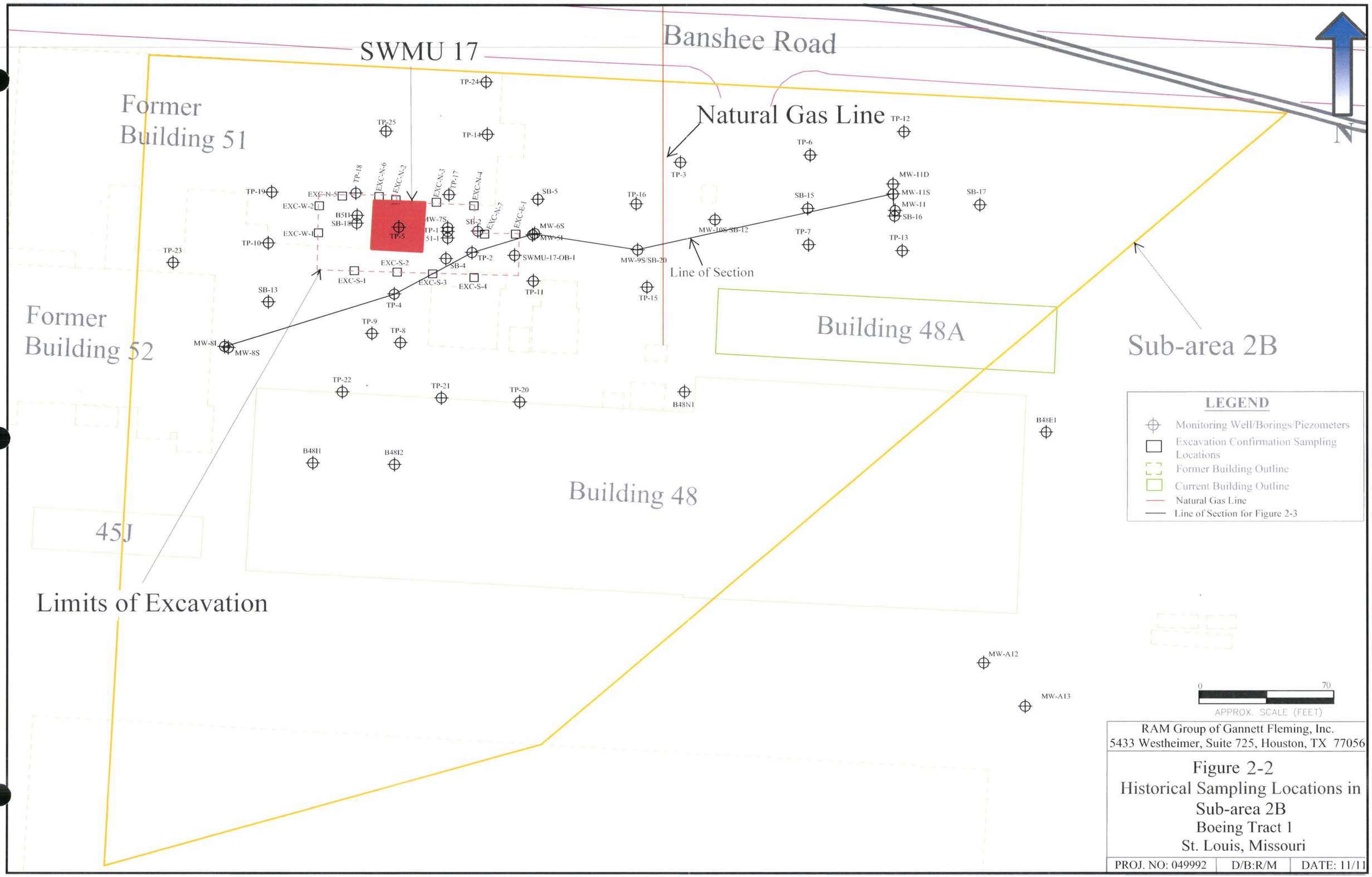
0 50

APPROX. SCALE (FEET)

RAM Group of Gannett Fleming, Inc.
5433 Westheimer Rd, Houston, TX 77057

Figure 2-1
SWMU 17 Data Points
Boeing Tract 1
St. Louis, Missouri

PROJ. NO. 054517	D/B: RM	DATE: 11/11



RAM Group of Gannett Fleming, Inc.
5433 Westheimer, Suite 725, Houston, TX 77056

Figure 2-2
Historical Sampling Locations in Sub-area 2B
Boeing Tract 1
St. Louis, Missouri

PROJ. NO: 049992	D/B:R/M	DATE: 11/11

2A | SWMU17 | 2B | 2C

Ground Surface

Natural Gas Line
(actual depth unknown)

Excavated Area

Zone of Injection IP-5

Zone of Injection IP-4&IP-6

Impacted Areas

Impacted Area &Zone of Injections IP-1,IP-2, IP-3

Weathered Limestone Rubble

Clay and Weathered Shale & Gravel

Geotech boring logs B1 and B4 were not available & not used in the interpretation. Also, boring B41S3D had no data below 44 ft bgs.

▼ Water Level Measurements 6/15/2011

LEGEND
- Fill
- Clayey Silt
- Organic Silt
- Clay
- Shale Bedrock
- Limestone Bedrock
- Clay & Gravel

RAM Group of
Gannett Fleming, Inc.
5433 Westheimer Rd, Suite 725,
Houston, TX 77056

Figure 2-3
Geologic Cross-Section of Sub-Area 2B
Boeing Tract 1
Hazelwood, Missouri
(Modified after MACTEC)

Sub-area 6B

NORTH LINDBERGH BOULEVARD

JAMES S. MCDONNELL BOULEVARD

BANSHEE ROAD

Sub-area 2B

MW10S 532.20

MW9S 530.15

MW8AS 523.20

MW5DS 523.61

MW6 511.88

RC13 531.29

RC15 534.53

RC14 532.00

MW3 531.02

MW3A 533.78

RC8D 532.61

MW3B 530.78

RC8S 532.44

B27W3D 532.91

B28MW3 533.83

B28MW1 532.96

B28MW4 533.24

B28MW2 534.47

MW7 535.15

TP-6 543.69

MW-6S 543.31

TP-3 543.36

MW-11S 542.16

SWMU17-CB-1 543.72

TP-4 543.84

MW-10S 541.68

MW-8S 541.91

MW-9S 543.11

MW-11I

MW-A6

B41MW-18 537.33

B4MW-9 523.12

B4MW-10 518.23

B42N6 534.31

MW-A13 533.83

MW-A26 535.12

MW-A25 536.41

MW-A27 536.29

MW-A3 534.20

MW-A1 532.84

MW-A4 524.92

540

535

530

525

520

515

N

LEGEND

- Monitoring Well Location
- 530 Groundwater Contour (dashed where inferred)
- Groundwater Flow Direction
- 533.83 Groundwater Elevation (ft)
- Railroad
- Roadway
- Building Outline

MW9S Sampled using Snap Sampler

RC8D Sampled using Low-Flow Purging and Sampling Method or Peristaltic Pump

Wells with LNAPL

MW-A3 Wells only gauged

0 400

APPROX. SCALE (FEET)

RAM Group of Gannett Fleming, Inc.
5433 Westheimer, Suite 725, Houston, TX 77056

Figure 2-4(a)
Shallow Zone Groundwater Contour Map
(June 15-17, 2011)
Boeing Tract 1
St. Louis, Missouri

August 2011/BR | RAM Group (054517)

Sub-area 6B

MW10D
534.57

533

531

529

527

525

523

521

519

517

515

MW8AD
524.52

MW6D
513.41

JAMES S. MCDONNELL BOULEVARD

NORTH LINDBERGH BOULEVARD

BANSHEE ROAD

525.21 MW-11D

Sub-area 2B

N

LEGEND

- Monitoring Well Location
- 531 Groundwater Contour (dashed where inferred)
- Groundwater Flow Direction
- 525.21 Groundwater elevation (ft)
- Railroad
- Roadway
- Building Outline

0 400

APPROX. SCALE (FEET)

RAM Group of Gannett Fleming, Inc.
5433 Westheimer, Suite 725, Houston, TX 77056

Figure 2-4(b)
Deep Zone Groundwater Contour Map
(June 15-17, 2011)
Boeing Tract 1
St. Louis, Missouri

August 2011/BR | RAM Group (054517)

N

Limits of Excavation

Industrial Sewer Line

Building 27

RC1
RC2
RC3
RC4
RC5
RC6D
RC6S
RC7
RC8D
RC8S
RC9
RC10
RC11
RC12
RC13
RC14
RC15
MW3
MW3A
MW3B
MW9D
MW9S
A
A'

LEGEND

- Monitoring Well (Shallow)
- Abandoned Monitoring Well
- Piezometer
- Abandoned Piezometer
- HRC Injection Point
- Current Building Outline
- Scrap Metal Recycling Dock
- Industrial Sewer Line
- A-A' Line of Section

0 30 60

APPROXIMATE SCALE (FEET)

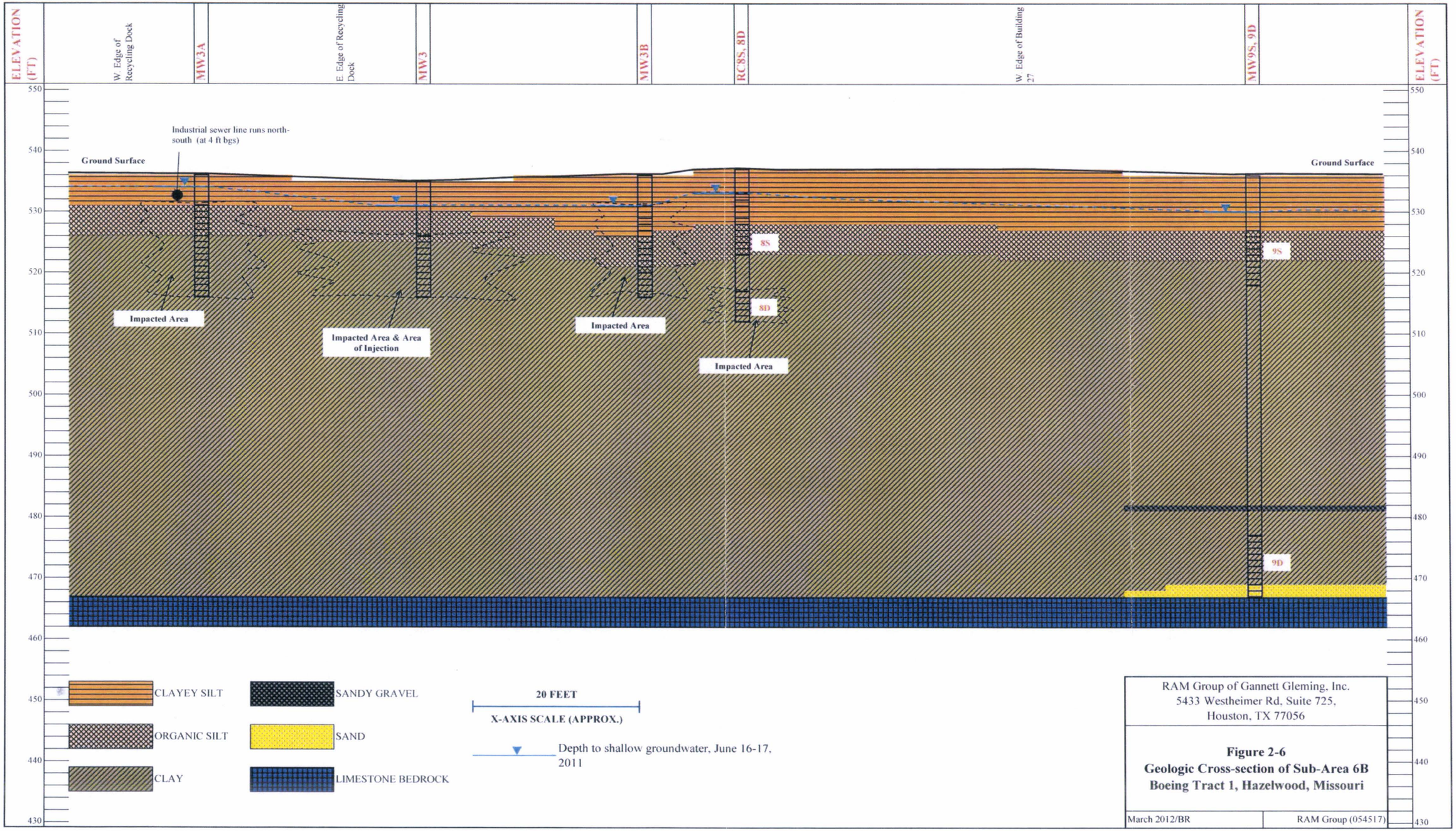
RAM Group of Gannett Fleming, Inc.
5433 Westheimer, Suite 725, Houston, TX 77056

Figure 2-5
Sub-area 6B (North) Data Points
Boeing Tract 1
St. Louis, Missouri

PROJ. NO: 054517	D/B:V/S	DATE:11/11

SOUTH WEST
A

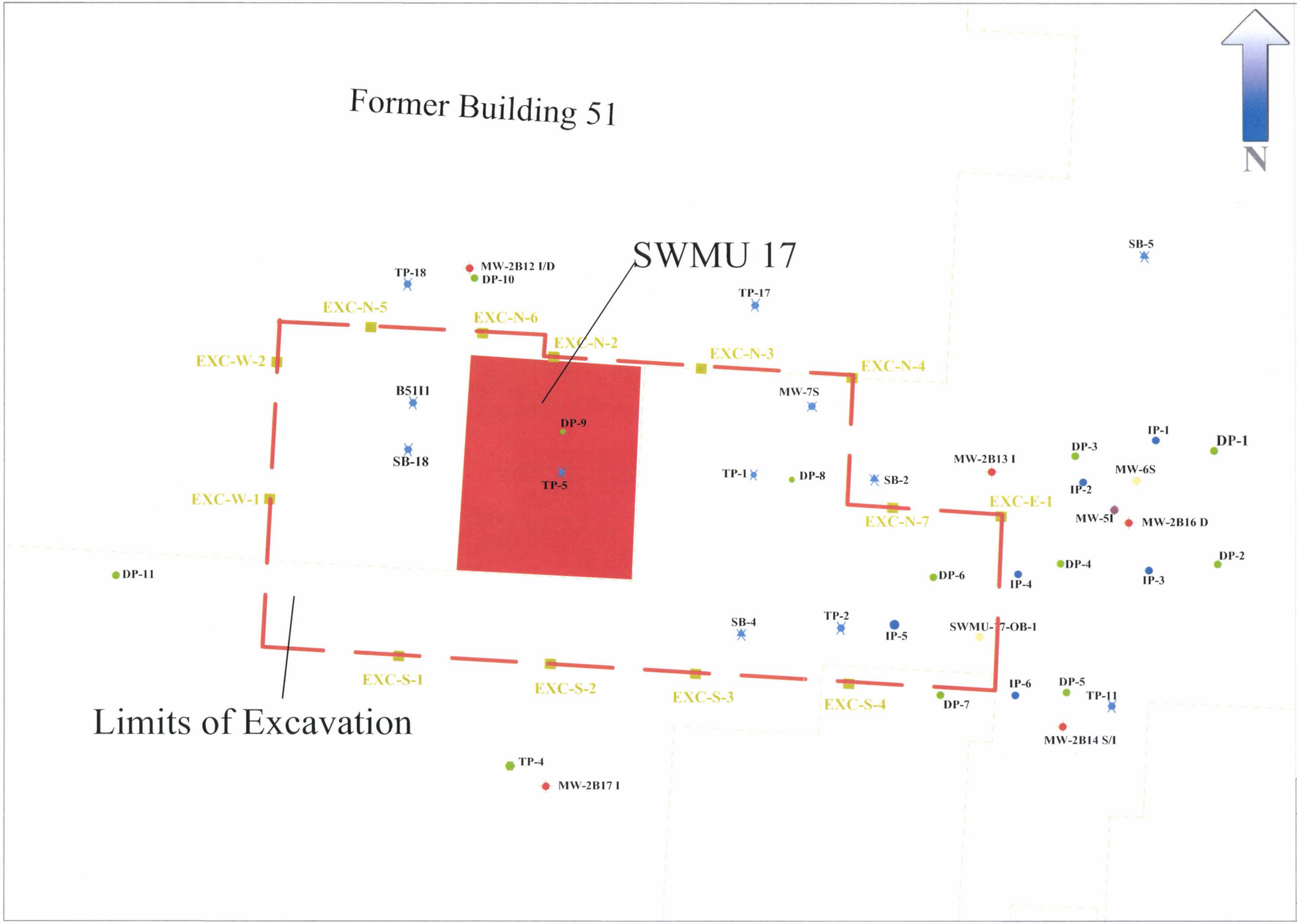
NORTH EAST
A'



RAM Group of Gannett Gleming, Inc.
5433 Westheimer Rd, Suite 725,
Houston, TX 77056

Figure 2-6
Geologic Cross-section of Sub-Area 6B
Boeing Tract 1, Hazelwood, Missouri

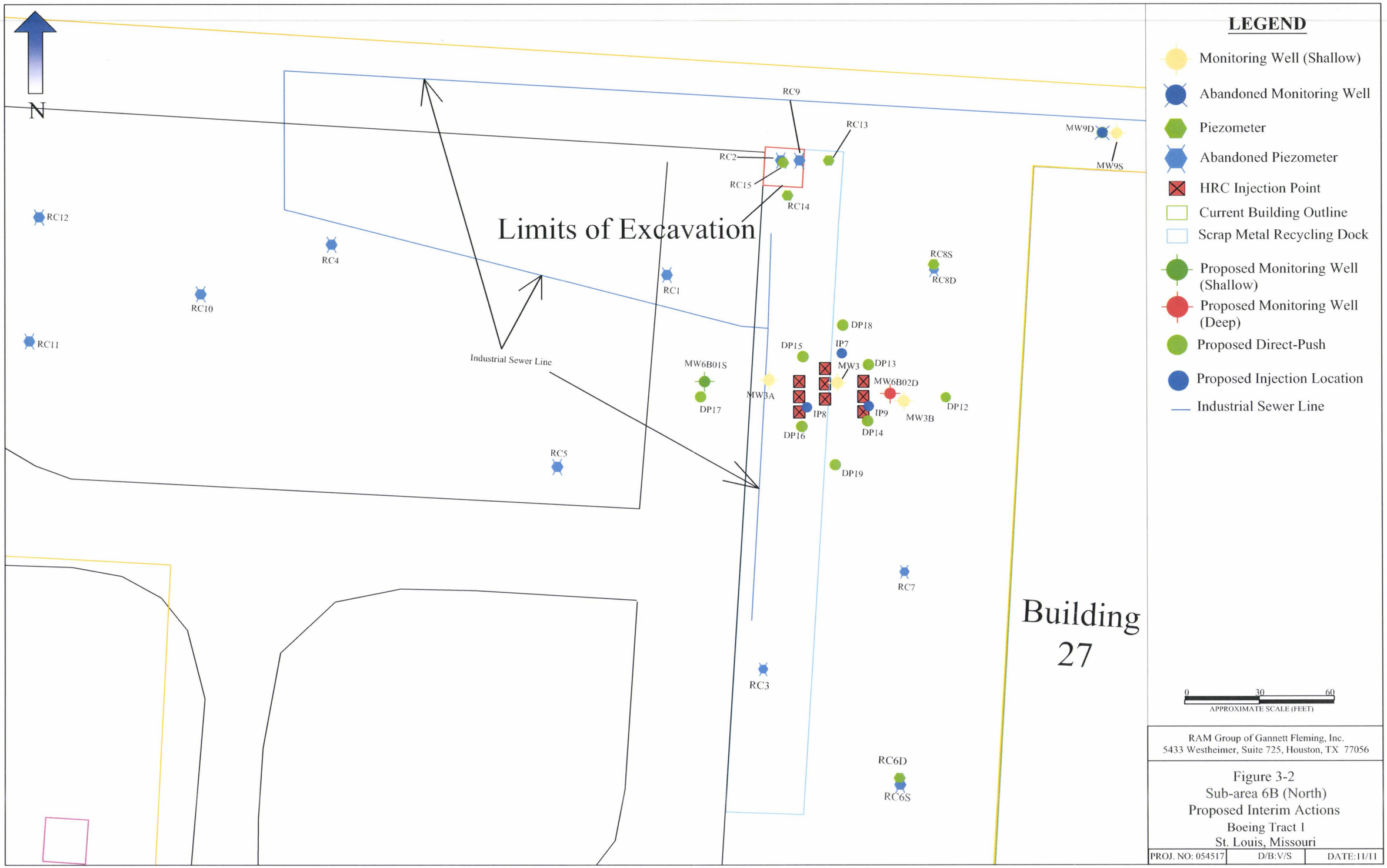
March 2012/BR | RAM Group (054517)



RAM Group of Gannett Fleming, Inc.
5433 Westheimer Rd, Suite #725, Houston, TX 77057

Figure 3-1
Sub Area 2B Proposed Interim Actions
Boeing Tract 1
St. Louis, Missouri

PROJ. NO: 054517	D/B: RM	DATE: 11/11



RAM Group of Gannett Fleming, Inc.
5433 Westheimer, Suite 725, Houston, TX 77056

Figure 3-2
Sub-area 6B (North)
Proposed Interim Actions
Boeing Tract 1
St. Louis, Missouri

PROJ. NO: 054517	D/B:V/S	DATE:11/11

APPENDIX A
RFI FIGURES

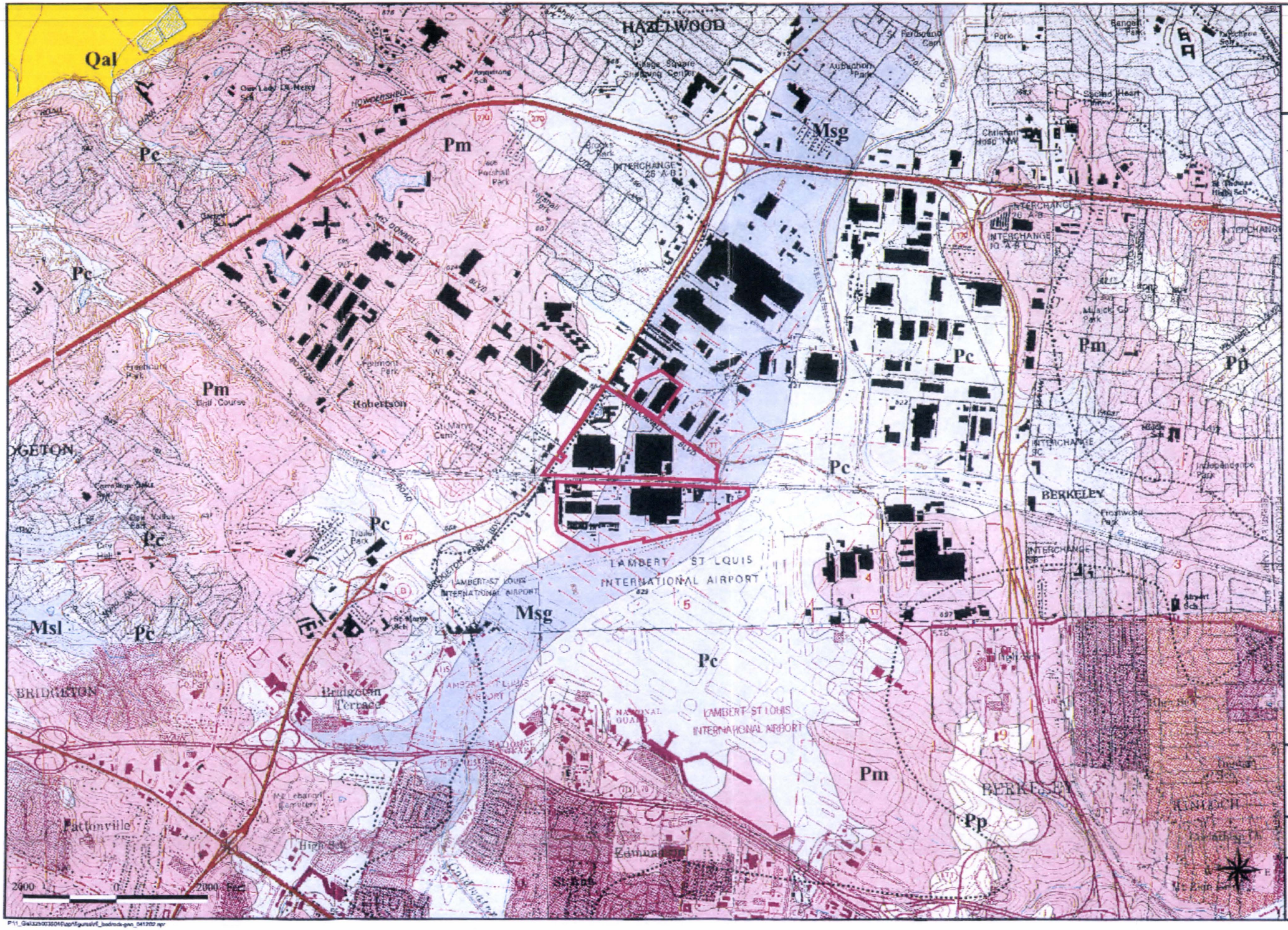


Figure 2-5
Regional Bedrock Geology Map
Boeing Tract 1 RFI
Hazelwood, Missouri

Legend

- Florissant Basin Boundary (approximate)
- Qal - Alluvium
- Pp - Pleasanton Group
- Pm - Marmaton Group
- Pc - Cherokee Group
- Msg - Ste. Genevieve Limestone
- Msl - St. Louis Limestone
- Boeing Tract 1

Source: Modified from Brill, 1991 and MDNR, 1987.

Scale

1:24000

1" – 2000'

Drawn by: EJW Approved by:

Checked by: BSM Date: December 7, 20

MACTEC

P:\1_Gis\325\035046\apr\figures\rfi_bedrock-geo_041202.apr

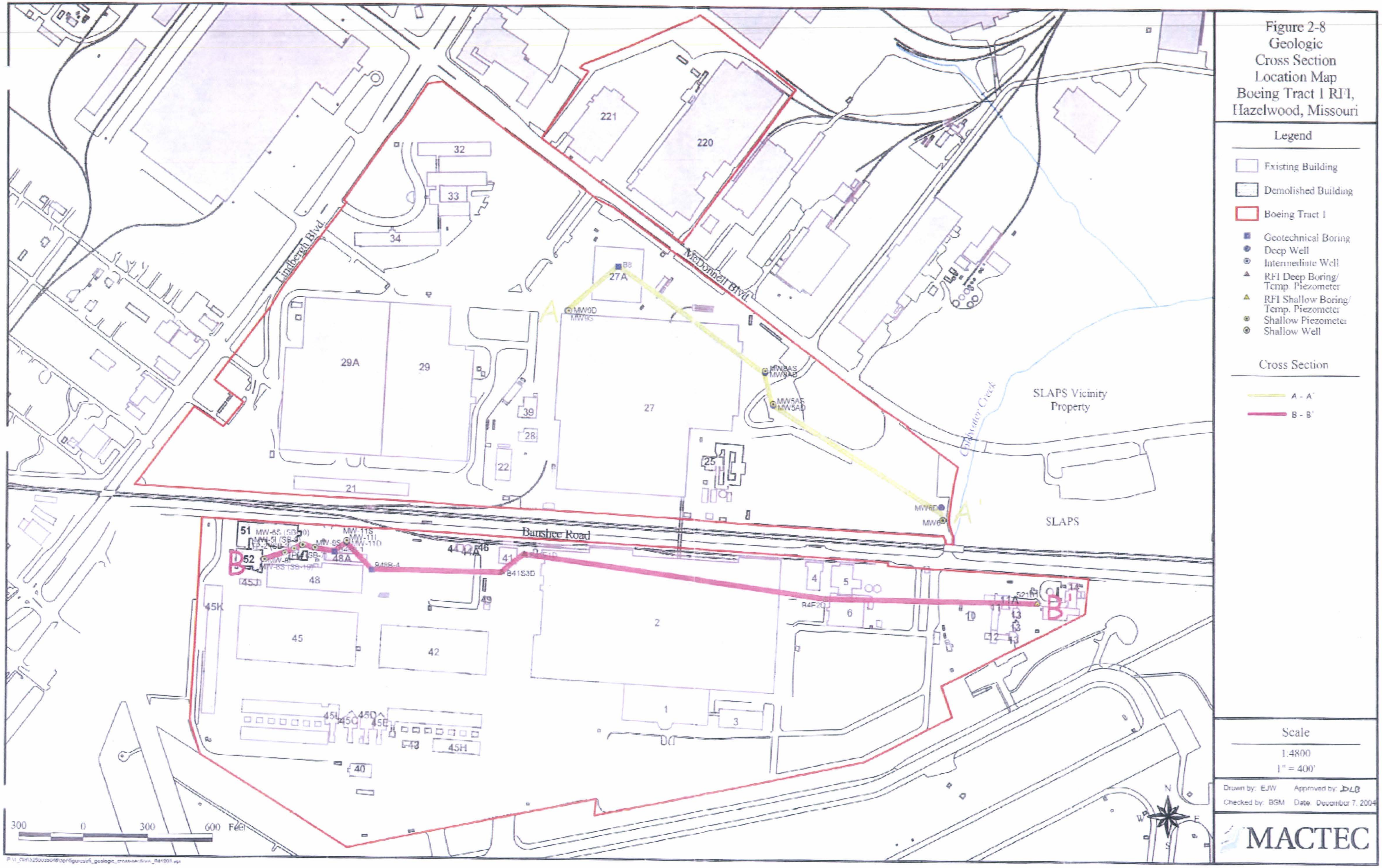
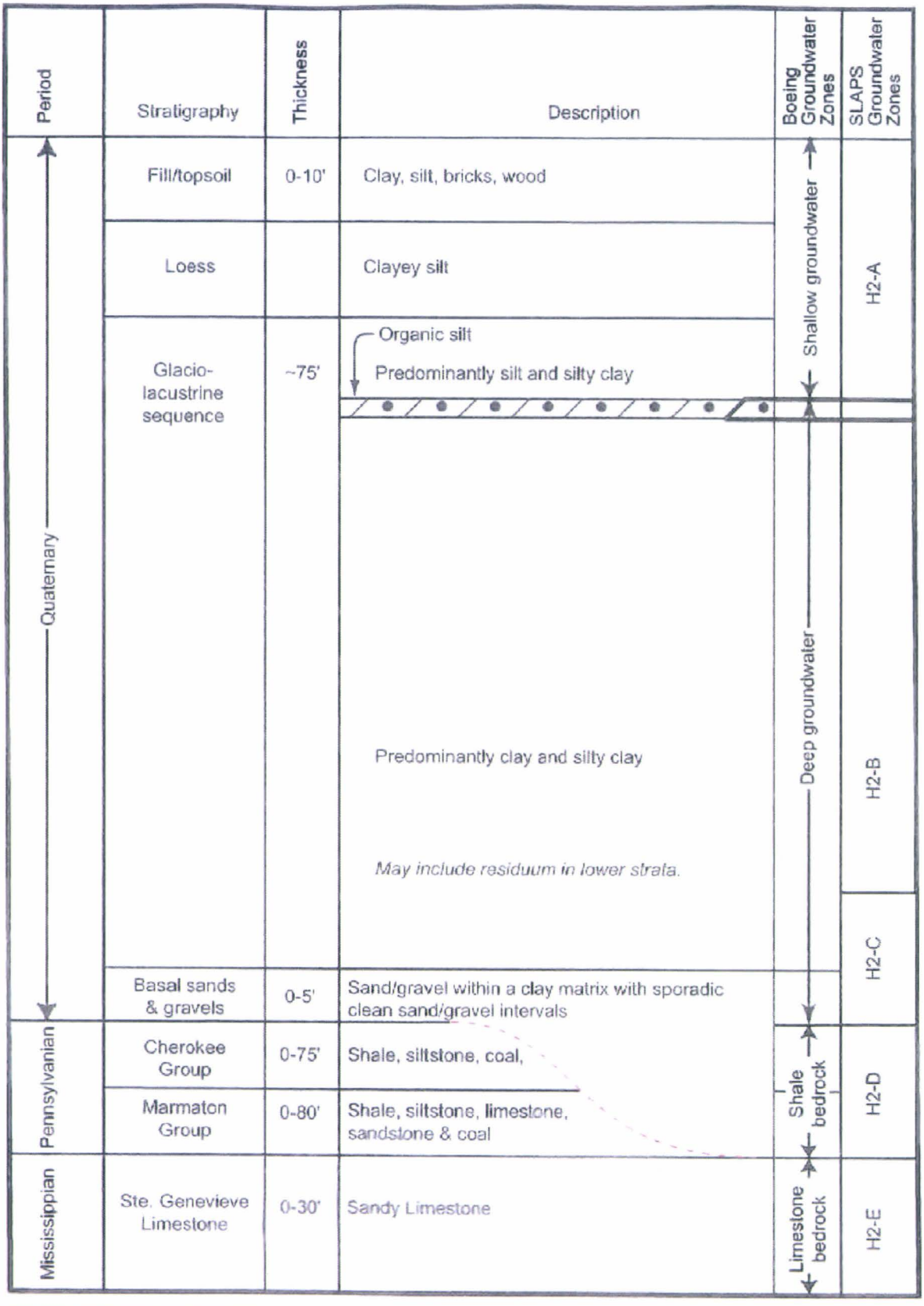


Figure 2-8
Geologic
Cross Section
Location Map
Boeing Tract 1 RFI,
Hazelwood, Missouri
Legend
Existing Building
Demolished Building
Boeing Tract 1
Geotechnical Boring
Deep Well
Intermediate Well
RFI Deep Boring/ Temp. Piezometer
RFI Shallow Boring/ Temp. Piezometer
Shallow Piezometer
Shallow Well
Cross Section
A - A'
B - B'
Scale
1:4800
1" = 400'
Drawn by: EJW
Approved by: DLB
Checked by: BGM
Date: December 7, 2004
MACTEC
300 0 300 600 Feet
Lindbergh Blvd.
McDonnell Blvd.
Banshee Road
SLAPS Vicinity Property
SLAPS
Coldwater Creek
221
220
32
33
34
29A
29
27A
27
39
28
22
21
25
51
52
48A
48
45J
45K
45
42
41
4
46
49
2
1
3
4
5
6
10
11A
12
13
45L
45C
45D
45E
45H
40
A
A'
B
B'
MW9D
MW9S
MW8AS
MW8AD
MW5AS
MW5AD
MW6D
MW6
B8
MW-11S
MW-11I
MW-11D
B41S3D
B48B-4
B4F2D



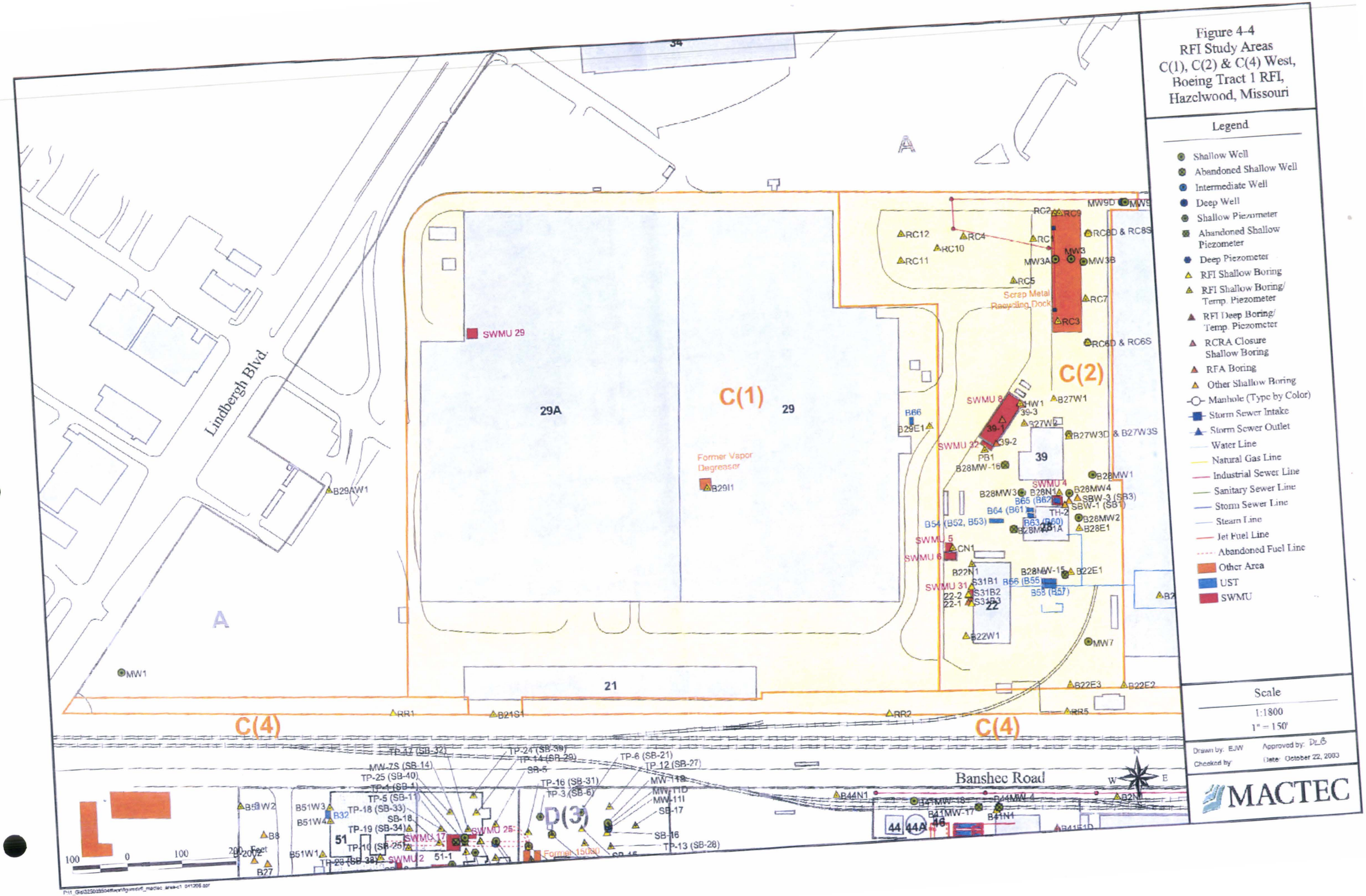
Drawn by: DEB Approved By: DLB

Checked by: SEG Date: 5/8/04

MACTEC

Figure 2-12
Generalized Hydrogeological Column and Comparison to SLAPS (HZ), Boeing Tract 1 RFI, Hazelwood, Missouri

Figure 4-4
RFI Study Areas C(1), C(2) & C(4) West, Boeing Tract 1 RFI, Hazelwood, Missouri



Legend

- Shallow Well
- Abandoned Shallow Well
- Intermediate Well
- Deep Well
- Shallow Piezometer
- Abandoned Shallow Piezometer
- Deep Piezometer
- RFI Shallow Boring
- RFI Shallow Boring/ Temp. Piezometer
- RFI Deep Boring/ Temp. Piezometer
- RCRA Closure Shallow Boring
- RFA Boring
- Other Shallow Boring
- Manhole (Type by Color)
- Storm Sewer Intake
- Storm Sewer Outlet
- Water Line
- Natural Gas Line
- Industrial Sewer Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Jet Fuel Line
- Abandoned Fuel Line
- Other Area
- UST
- SWMU

Scale
1:1800
1" = 150'

Drawn by: EJW
Checked by:
Approved by: DLB
Date: October 22, 2003

MACTEC

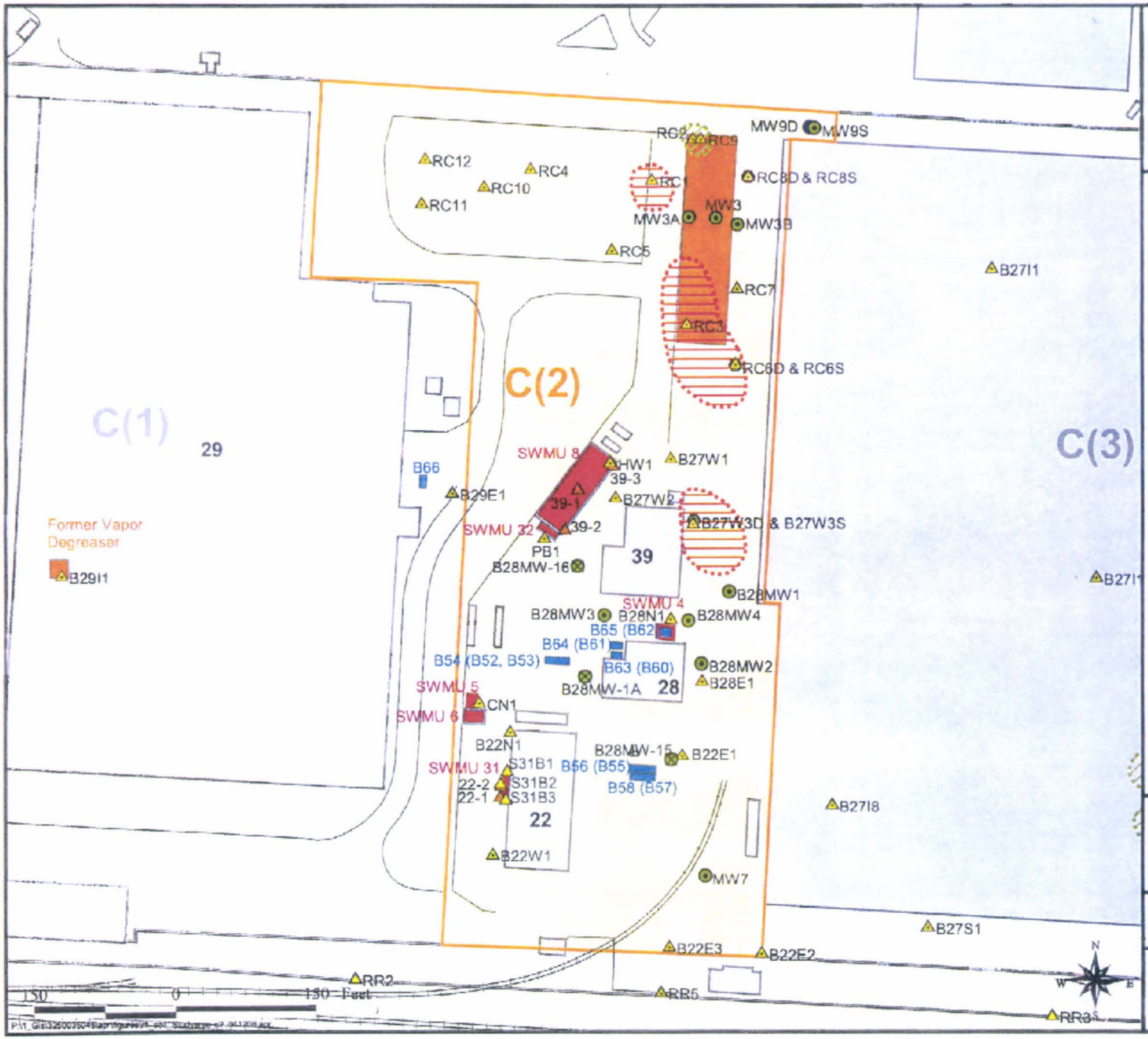


Figure 4-5
Soil Detections
Above ITLs
Study Area C(2),
Boeing Tract 1 RFI,
Hazelwood, Missouri

Legend

- Shallow Well
- Abandoned Shallow Well
- Intermediate Well
- Deep Well
- Shallow Piezometer
- Abandoned Shallow Piezometer
- Deep Piezometer
- RFI Shallow Boring
- RFI Shallow Boring/ Temp. Piezometer
- RFI Deep Boring/ Temp. Piezometer
- RCRA Closure Shallow Boring
- RFA Boring
- Other Shallow Boring
- Other Area
- UST
- SWMU
- Tetrachloroethene (PCE), Trichloroethene (TCE), and/or Breakdown Products
- Total Petroleum Hydrocarbon (TPH)

Scale

1:1800

1" = 150'

Drawn by: BSM Approved by: DLB

Checked by: Date: May 6, 2004

MACTEC

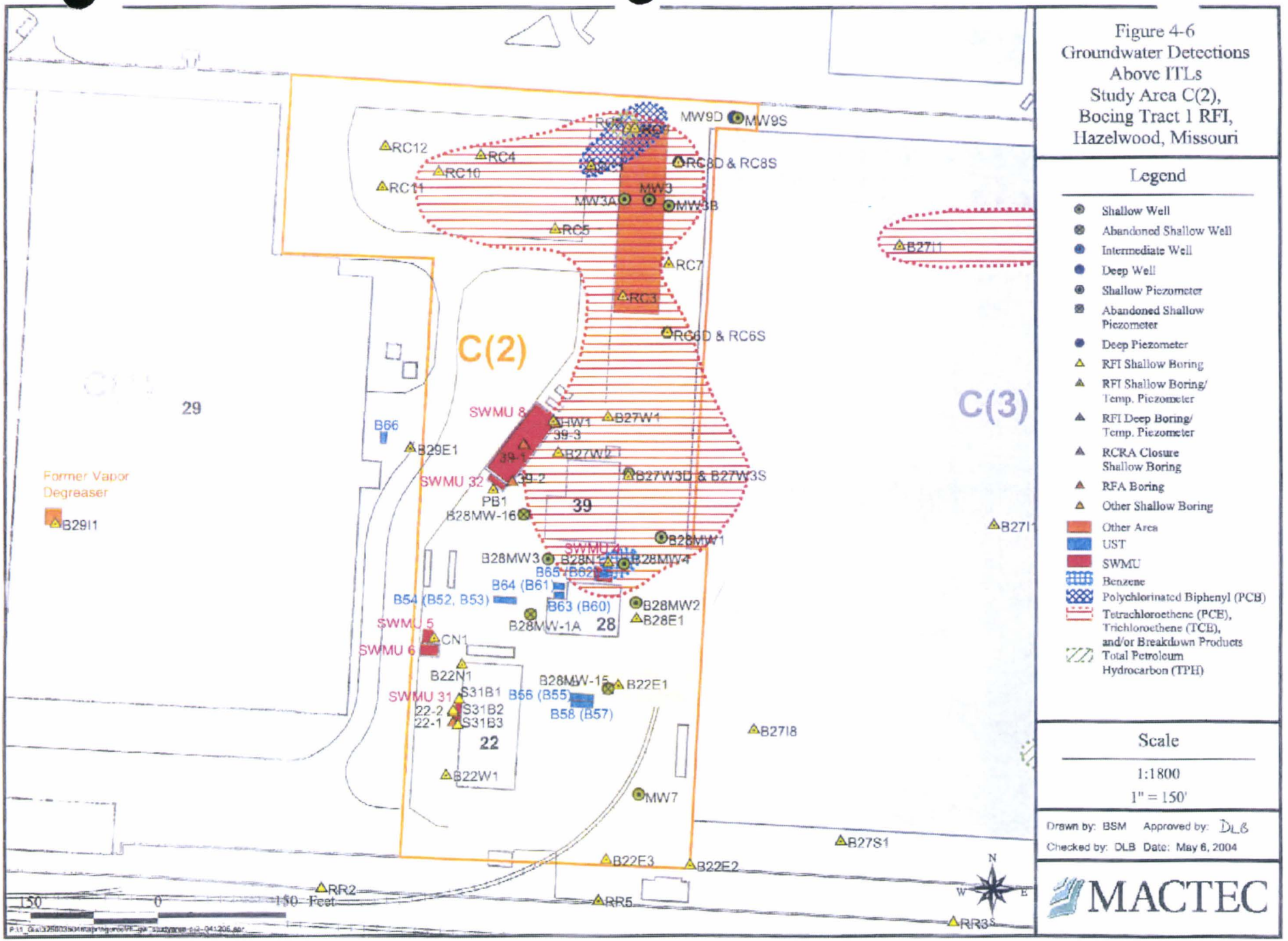


Figure 4-6
Groundwater Detections Above ITLs
Study Area C(2),
Bocing Tract 1 RFI,
Hazelwood, Missouri

Legend

- Shallow Well
- Abandoned Shallow Well
- Intermediate Well
- Deep Well
- Shallow Piezometer
- Abandoned Shallow Piezometer
- Deep Piezometer
- RFI Shallow Boring
- RFI Shallow Boring/ Temp. Piezometer
- RFI Deep Boring/ Temp. Piezometer
- RCRA Closure Shallow Boring
- RFA Boring
- Other Shallow Boring
- Other Area
- UST
- SWMU
- Benzene
- Polychlorinated Biphenyl (PCB)
- Tetrachloroethene (PCE), Trichloroethene (TCE), and/or Breakdown Products
- Total Petroleum Hydrocarbon (TPH)

Scale

1:1800

1" = 150'

Drawn by: BSM Approved by: DLB

Checked by: DLB Date: May 6, 2004

MACTEC

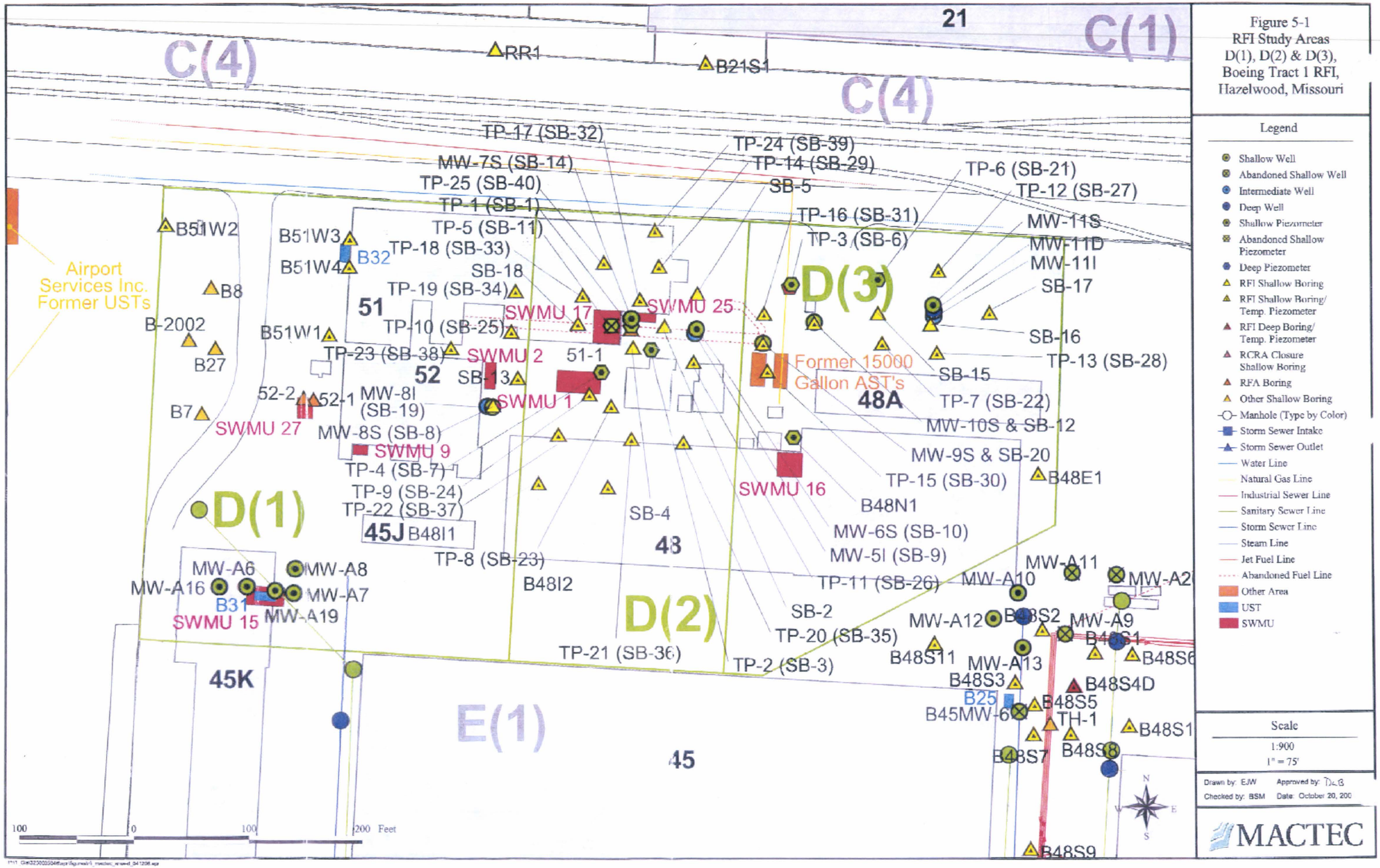


Figure 5-1
RFI Study Areas
D(1), D(2) & D(3),
Boeing Tract 1 RFI,
Hazelwood, Missouri

Legend

- Shallow Well
- Abandoned Shallow Well
- Intermediate Well
- Deep Well
- Shallow Piezometer
- Abandoned Shallow Piezometer
- Deep Piezometer
- RFI Shallow Boring
- RFI Shallow Boring/ Temp. Piezometer
- RFI Deep Boring/ Temp. Piezometer
- RCRA Closure Shallow Boring
- RFA Boring
- Other Shallow Boring
- Manhole (Type by Color)
- Storm Sewer Intake
- Storm Sewer Outlet
- Water Line
- Natural Gas Line
- Industrial Sewer Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Jet Fuel Line
- Abandoned Fuel Line
- Other Area
- UST
- SWMU

Scale
1:900
1" = 75'

Drawn by: EJW Approved by: DLB
Checked by: BSM Date: October 20, 200

MACTEC

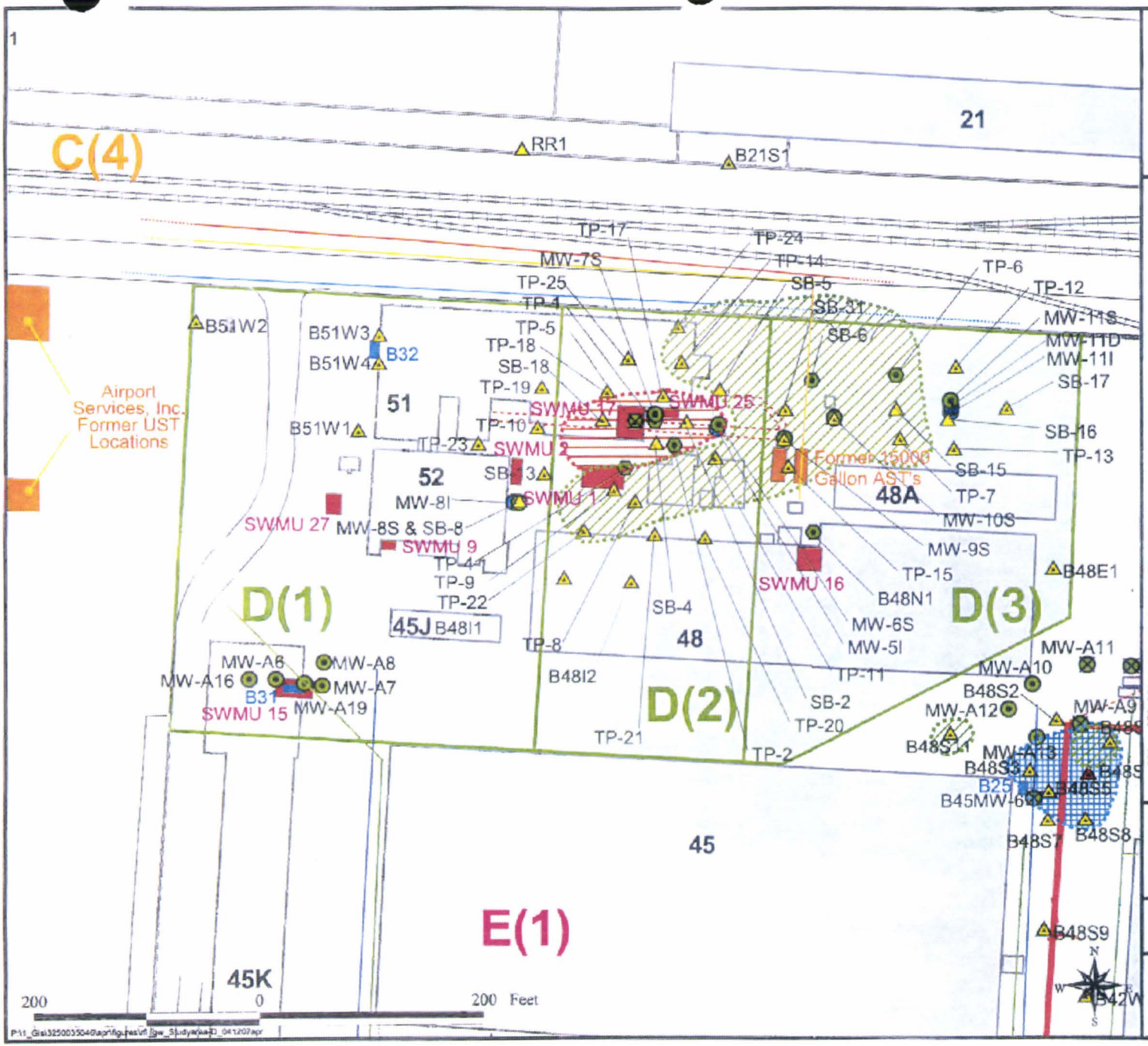


Figure 3-2
Soil Detections
Above ITLs
Study Area D,
Boeing Tract 1 RFI,
Hazelwood, Missouri

Legend

- Shallow Well
- Abandoned Shallow Well
- Intermediate Well
- Deep Well
- Shallow Piezometer
- Abandoned Shallow Piezometer
- Deep Piezometer
- RFI Shallow Boring
- RFI Shallow Boring/Temp. Piezometer
- RFI Deep Boring/Temp. Piezometer
- RCRA Closure Shallow Boring
- RFA Boring
- Other Shallow Boring
- Jet Fuel Line
- Abandoned Fuel Line
- Natural Gas Line
- Water Line
- Other Area
- UST
- SWMU
- Benzene
- Tetrachloroethene (PCE), Trichloroethene (TCE), and/or Breakdown Products
- Total Petroleum Hydrocarbon (TPH)

Scale

1:1500

1" = 125'

Drawn by: EJW Approved by:

Checked by: BSM Date: December 7, 2004

MACTEC

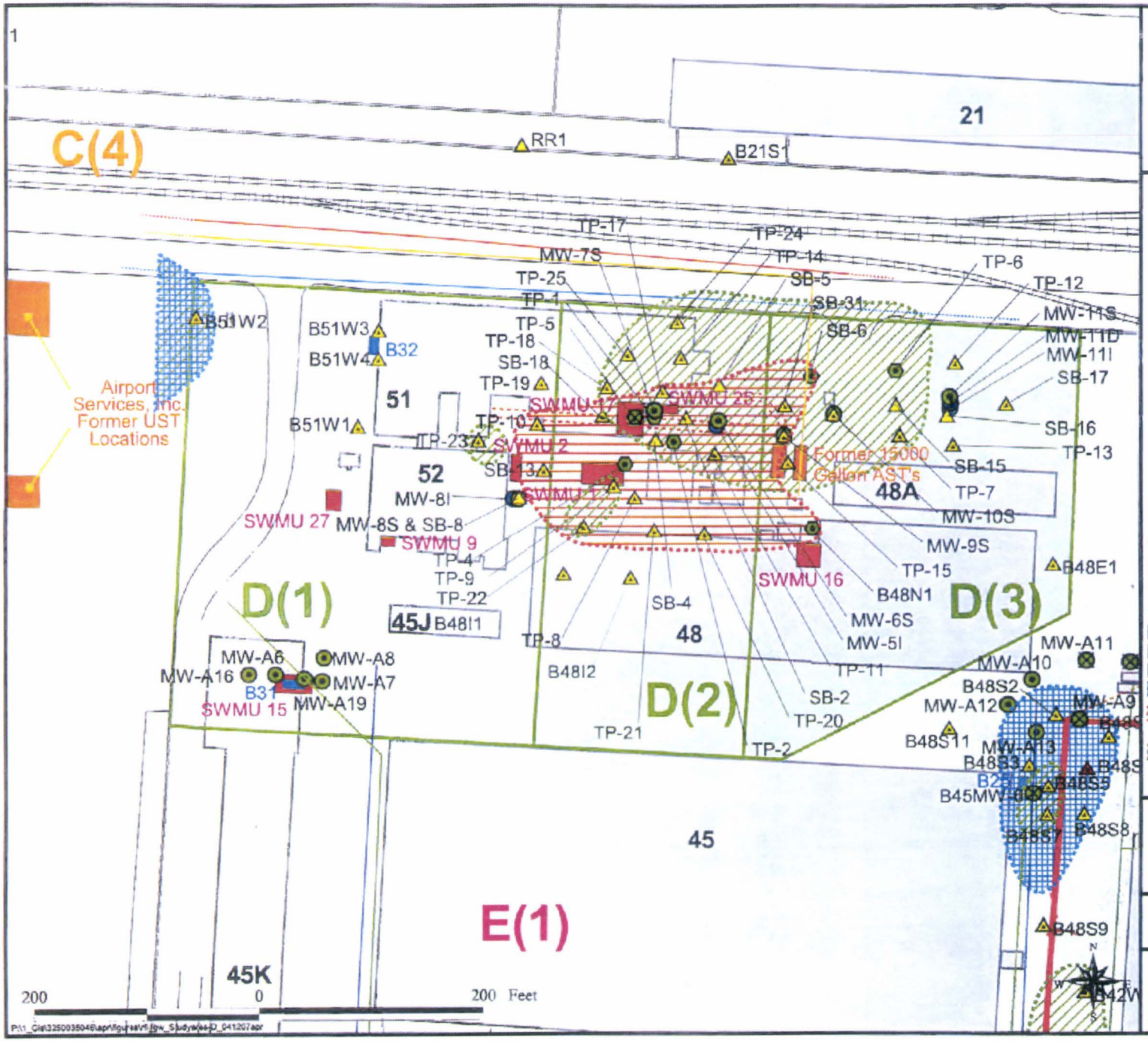


Figure 5-3
Groundwater Detections
Above ITLs
Study Area D,
Boeing Tract 1 RFI,
Hazelwood, Missouri

Legend

- Shallow Well
- Abandoned Shallow Well
- Intermediate Well
- Deep Well
- Shallow Piezometer
- Abandoned Shallow Piezometer
- Deep Piezometer
- RFI Shallow Boring
- RFI Shallow Boring/Temp. Piezometer
- RFI Deep Boring/Temp. Piezometer
- RCRA Closure Shallow Boring
- RFA Boring
- Other Shallow Boring
- Jet Fuel Line
- Abandoned Fuel Line
- Natural Gas Line
- Water Line
- Other Area
- UST
- SWMU
- Benzene
- Tetrachloroethene (PCE), Trichloroethene (TCE), and/or Breakdown Products
- Total Petroleum Hydrocarbon (TPH)

Scale

1:1500

1" = 125'

Drawn by: EJW Approved by: DCS

Checked by: BSM Date: December 7, 2004

MACTEC